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ABSTRACT

The Advanced Systems Division of the Air Force Human Resources Laboratory, Air Force Systems Command conducts research and development in the areas of training techniques, psychological and engineering aspects of training equipment, and personnel and training factors in the design of new systems and equipment. This unclassified, unlimited annotated bibliography lists the memorandum reports, technical reports, and journal articles prepared by the Advanced Systems Division from 1950 until the end of 1972. The citations are arranged chronologically by year and alphabetically by author within each year. Three indexes are included: (1) the Author, Category, and Abstract Number Index, (2) Subject Index, and (3) the Memorandum Reports, Technical Notes, and Technical Reports Index. (Author)

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AIR FORCE
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ED 075714

ANNOTATED BIBLIOGRAPHY OF THE ADVANCED SYSTEMS DIVISION REPORTS
(1950 - 1972)

By

Horace H. Valverde
Helen E. Lebkisher
Arlene Reynolds

ADVANCED SYSTEMS DIVISION
Wright-Patterson Air Force Base, Ohio 45433

March 1973

Approved for public release; distribution unlimited.

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AIR FORCE HUMAN RESOURCES LABORATORY
AIR FORCE SYSTEMS COMMAND
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FOREWORD

This report presents an unclassified, unlimited annotated bibliography of technical reports and other publications on research conducted by the Advanced Systems Division, Air Force Human Resources Laboratory (AFHRL). The cited references cover the period July, 1950 through December, 1972.

Dr. Ross L. Morgan assigned the abstracts to the various categories. Dr. Gordon A. Eckstrand provided overall technical guidance in the preparation of this report. Suggestions and editorial assistance were provided by Dr. William B. Askren.

The reports listed in this annotated bibliography are not obtainable from the Air Force Human Resources Laboratory. Except for journal articles, microfilm (or microfiche, since 1 August 1965), and reproduced paper copies may be purchased from:

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This report was submitted on 6 February 1973.

This report has been reviewed and approved.

HAROLD E. FISCHER, Colonel, USAF
Commander

ABSTRACT

The Advanced Systems Division of the Air Force Human Resources Laboratory, Air Force Systems Command conducts research and development in the areas of training techniques, psychological and engineering aspects of training equipment, and personnel and training factors in the design of new systems and equipment. This unclassified, unlimited annotated bibliography lists the memorandum reports, technical reports, and journal articles prepared by the Advanced Systems Division from 1950 until the end of 1972. The citations are arranged chronologically by year and alphabetically by author within each year. Three indexes are included: (1) the Author, Category, and Abstract Number Index, (2) Subject Index, and (3) the Memorandum Reports, Technical Notes, and Technical Reports Index.

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INTRODUCTION

The prime mission of the Advanced Systems Division of the Air Force Human Resources Laboratory (AFHRL) is concerned with the human side of weapon system development. The Division is responsible for developing technology in several areas which are critical to adequate planning for human components in system development. These include responsibility for developing (1) data and techniques for assuring that systems are developed in such a way that the Air Force can provide the required human resources support at a cost which is reasonable and in balance with other demands on the Air Force dollar; (2) technology required to build the simulators and training equipment the Air Force needs in order to provide safe, effective and economical training for its aircrew and maintenance personnel; and (3) new concepts and techniques for the solution of unique and critical training problems associated with new systems and advanced technology.

The program of the Advanced Systems Division has evolved steadily during the past 22 years. Several organizational changes have occurred during this period. However, sufficient organizational continuity has been maintained to justify and permit this compilation of reports by the Division. Until 1 July 1968, the Advanced Systems Division, then known as the Training Research Division, was a part of the Aerospace Medical Research Laboratory (AMRL), Aerospace Medical Division. On that date, the Air Force Human Resources Laboratory (AFHRL) was established and the Training Research Division became an element of AFHRL. The Division's name was changed to Advanced Systems Division on 1 June 70 to more adequately reflect our primary mission with the Laboratory.

AMRL continued to give editorial and publication support for all reports which had been submitted to it by the Division prior to the establishment of AFHRL. Reports prepared by the Division after 1 July 1968, and published between 1 July and 31 December 1968, may have been published by AMRL or AFHRL. The Advanced Systems Division has conducted several joint reconnaissance research studies with Air Force Avionics Laboratory (AFAL), Wright-Patterson Air Force Base, Ohio. The results of these studies, published as AFAL technical reports are included in this bibliography.

The annotated bibliography is a compilation of abstracts pertaining to unclassified, unlimited technical reports, and memorandum reports (also journal articles) prepared by personnel of the Advanced Systems Division. The 415 abstracts are arranged chronologically by year and alphabetically by author within each year. The compilers prepared abstracts for a few journal articles where no abstracts were available. Otherwise the abstracts contained in this report are those prepared by the respective authors.

The purpose of this annotated bibliography is to provide a convenient source of information concerning the research efforts performed by the Advanced Systems Division personnel. The abstracts are intended to convey only a general brief of the content of cited publications. However, the abstracts should provide research and training personnel with sufficient information to enable them to decide whether any particular report should be obtained for further study. Therefore, it is suggested that conclusions should not be based solely upon the information contained in the abstracts because often the complete reports include certain reservations or qualifications concerning obtained results.

ABSTRACT FOR 1950

1. Eckstrand, G. A., *Response Practice as a Factor in Transfer of Training*, AF Technical Report 6017, July 1950. ATI 82 501.

In some types of training devices it is relatively easy to simulate accurately the manual responses required of the operator in the actual task but difficult and expensive (in some cases, impossible) to simulate in detail the stimuli to which these responses are made. Consequently, it becomes of interest to ask whether or not practice on the responses required in a task alone will be of value in training an operator to perform the total task. This report describes an experiment which bears on this question. It was found that, in terms of speed of response, pre-training practice of the responses required in a perceptual-motor task produced positive transfer to the learning of that task even though the stimuli during the pre-training were unrelated to those of the final task. In terms of errors, only the group having the greatest amount of pre-training evidenced positive transfer. These results are interpreted in terms of theoretical viewpoint described in the report and the implications for training device design are pointed out.

ABSTRACT FOR 1951

2. Eckstrand, G. A., *Cue Attention Habits as a Factor in Training*, AF Technical Report 6566, August 1951. ATI 122 739.

Three groups of 40 subjects each learned a discriminative motor task which required that they associate four different response keys with four different colored forms. In this standard task both Color and Form were relevant cues, i.e., either stimulus aspect could be used to perform successfully on the task. Before learning this standard task, each of the groups had a different kind of preliminary training. Group A learned tasks in which Form was always relevant and Color always relevant. Group B learned tasks in which Color was always relevant and Form always irrelevant. Group C learned tasks in which both Form and Color were relevant. The forms and colors used in these preliminary tasks were different from those used in the standard task. In order to determine whether or not the preliminary training had a selective influence on which one of the relevant cues in the standard task was used to solve the problem, each of the groups was divided into two sub-groups. In each case one sub-group learned a test task with only the forms from the standard task present and the other sub-group a test-task with only the standard task colors present. All learning was to a criterion. The test-task with only forms present was learned most rapidly by Group B. The situation was reversed in the learning of the test-task with only colors present. The results support the conclusion that cue attention habits established during training transfer to the learning of later, similar tasks. Implications for training design are discussed.

ABSTRACTS FOR 1952

3. Duncan, C. P. and Underwood, B. J., *Transfer of Training in Motor Learning as a Function of Degree of First-Task Learning and Inter-Task Similarity*, WADC Technical Report 52-64, April 1952. ATI 172 519.

Transfer between a first and a second task, both available on the same piece of equipment, was studied as a function of degree of learning of the first task and of degree of similarity between tasks. There were four degrees of first-task learning, defined by the number of practice trials, and three degrees of inter-task similarity, defined by the number of stimuli and responses newly paired on the second task. It was found that acquisition of the second task was facilitated by practice on the first task, and that the facilitation increased directly with degree of first-task learning. Positive transfer also occurred with all degrees of inter-task similarity, and increased directly as a similarity increased. Differential positive transfer resulting from variation of first-task learning lasted throughout all 60 acquisition trials on the second task; inter-task similarity produced differential positive transfer during only the first 30 trials.

4. Duncan, C. P. and Underwood, B. J., *Retention of Transfer in Motor Learning after 24 Hours and after 14 Months as a Function of Degree of First-Task Learning and Inter-Task Similarity*, WADC Technical Report 52-224, October 1952. AD 3247.

Retention of a transfer provided on a self-paced discriminative motor device was studied as a function of degree of learning of the training task and similarity between tasks. Retention of the transfer task was measured after 24 hours and again after 14 months following acquisition. There was some forgetting over 24 hours but in relearning the positive transfer obtained during acquisition of the transfer task continued to be manifest and to vary directly both with degree of first-task learning and with task similarity. Proactive facilitation of retention was obtained. Forgetting over 14 months was great and showed evidence for differential proactive inhibition as a function of degree of learning. Relearning proceeded relatively rapidly. Performance during relearning varied directly with degree of first-task learning but did not vary with inter-task similarity.

5. Eckstrand, G. A., *Studies in Cue Utilization Behavior: I. The Influence of a Relevant but "Unused" Cue in Training Upon Transfer in a Positive Transfer Situation*, WADC Technical Report 52-79 (I), April 1952. ATI 164 224.

In a training device or simulator an attempt is made to provide the primary stimulus cues which exist in the operational equipment or situation for which the student is being trained. In a simulator, however, additional or secondary cues may be introduced unintentionally which the student can use to obtain successful performance. If such secondary cues are available and used by the student, will he also learn to use those which are primary and must be relied upon in the operational situation? In four separate experiments directed toward this question subjects learned, on the basis of a secondary cue, a task which also contained a "primary" cue. They were then forced to perform the task on the basis of the "primary" cue alone. Their performance was compared with that of subjects who had not experienced the "primary" cue during learning. The results of these experiments support the hypothesis that little or nothing is learned about performing a task on the basis of the "primary" cue while learning is occurring on the basis of a secondary cue. The results point-up the potential inadequacy of any training device which permits successful performance in the device on the basis of cues other than those which permit successful performance in the operational situation.

6. Montgomery, V. E., Duncan, C. P. and Underwood, B. J., *Transfer of Training in Motor Learning as a Function of Distribution of Practice*, WADC Technical Report 52-115, October 1952. AD 3242.

Transfer between a first and a second task, both available on the same piece of equipment, was studied as a function of the distribution of practice on both the first and the second task. There were two experiments. In the first and the second tasks; all trials on any one day were separated by 10-second rests. In the second experiment practice within a day was continuous (0 second inter-trial rest). All trials on the first task were given on one day and two degrees of distribution of practice over days were used for the second task. All groups in both experiments were given the same total amount of practice. In the first experiment distribution of trials over days did not produce differential performance on either the first or second tasks. Positive transfer to the second task was the same for all groups; transfer was not found to vary as a function of distribution of practice trials over days. In the second experiment acquisition of the second task did not vary as a function of the distribution of continuous-practice trials over days. When the two experiments were compared, it was found that performance late in practice was poorer in groups given continuous trials in comparison with groups given 10-second inter-trial rests. This was found on both the first and second tasks. There was no difference between the two experiments in transfer to the second task; equal positive transfer was found regardless of whether practice was with or without inter-trial rests.

7. Wickens, D. D., *An Interpretation of the Development of a Perceptual Set in S-R Terms*, WADC Technical Report 52-305, September 1952. AD 5008.

This report is an effort to interpret the development of certain types of perceptual biases in terms of modern stimulus-response theory, and thus to integrate this class of behavior with concepts that have been found to be widely useful in handling other kinds of behavior. The specific type of situation with which this theoretical formulation is concerned is that in which certain classes of stimuli are seen as being relevant to problem solution and others as irrelevant. The paper is concerned primarily with predicting what will happen when the subject is transferred to a new situation where opportunity for the operation of these relevancies and irrelevancies occurs. The major assumptions employed were those of stimulus and response generalization, and the acquisition of excitatory tendencies through reinforcement and of inhibitory tendencies through non-reinforcement. A number of experimental predictions were generated by use of these concepts.

ABSTRACTS FOR 1953

8. Duncan, C. P., "Transfer in Motor Learning as a Function of Degree of First-Task Learning and Inter-Task Similarity," *Journal of Experimental Psychology,* 45: 1-11, 1953.

Subjects first learned which of 6 lever positions were associated with each of 6 colored lights. The task was subject paced. After 4 different degrees of learning, the light-slot relationships were shifted to provide 3 degrees of similarity between the first light-slot relationship and the second. The results indicated that transfer increased directly with both the degree of first task learning and inter-task similarity. Transfer was positive for all conditions. Transfer effects due to the degree of learning persisted throughout performance of the second task, while the effects of inter-task similarity were more transitory. The transfer was attributed to response generalization and learning-how-to-learn.

9. Duncan, C. P. and Underwood, B. J., "Retention of Transfer in Motor Learning after Twenty-Four Hours and after Fourteen Months," *Journal of Experimental Psychology,* 46: 445-452, 1953.

Acquisition and retention of a transfer task were studied as a function of two variables: degree of learning of the training task and similarity between tasks. The task involved associating colored lights and movements of a lever. The task was subject paced. The transfer task was obtained by revising the assignment of light to lever movements. The transfer task was relearned, once after a 24-hour interval and again after an interval of approximately 14 months. Although there was significant loss in proficiency after 24-hours, relearning was rapid and both variables were influential. After the 14-month interval, for all conditions, performance was poorer than when the subjects were first introduced to the task. Relearning the task after 14 months was quite rapid and was benefitted by increased original learning. Similarity had no influence on relearning. These results offer some support to the hypotheses that proaction inhibition increases as the retention interval increases.

10. Duncan, C. P. and Underwood, B. J., *Spatial Error Gradients in Motor Learning and Transfer,* WADC Technical Report 53-65, April 1953. AD 13 029.

Learning of, and transfer between, two perceptual-motor paired-associates tasks were studied by means of a detailed examination of errors. It was found that as a result of practice on the training task there developed a gradient of errors among the responses within the task. The gradient was based upon spatial response similarity; the more similar an error response was to the correct response, the more frequently did it occur as an error. These considerations held only for the first error made to each stimulus; there was no gradient among subsequent errors. Upon transferring to the second task the error gradient was greatly distorted by the tendency to make, as an error, the response that was previously correct on the training task.

As practice on the transfer task continued, there was some tendency for the original error gradient to become re-established. Errors decreased with practice but the rate of decrease was slower for the error of returning to the formerly correct response. These results show the need for having the arrangement of equipment in training simulators as similar as possible to the arrangement of operational equipment for which the operator is being trained. They also emphasize the need for standardization in aircraft cockpits and crew stations. Errors of operation are most likely to occur if controls which are very similar in location and method of operation serve different functions (e.g., on function in a simulator and another in an airplane).

11. Eckstrand, G. A. and Morgan, R. L., *A Study of Verbal Mediation as a Factor in Transfer of Training*, WADC Technical Report 53-34, February 1953. AD 13 030.

There are situations where positive transfer is desired between two tasks and where it is not possible or desirable to select or design the tasks so that positive transfer can be expected on the basis of the similarity relationships which exist. This study investigated one technique of producing transfer between tasks involving physically dissimilar sets of stimuli. This technique involves learning to make the same naming responses to the two sets of dissimilar stimuli. It was found that if the same verbal responses (color names) were learned to a set of six color stimulti and to a set of six nonsense forms, motor responses learned to the color stimuli were more readily learned to the forms than was the case when different verbal responses were learned to the two different kinds of stimuli.

12. Levine, M., *Tracking Performance as a Function of Exponential Delay Between Control and Display*, WADC Technical Report 53-236, October 1953. AD 26 450.

Eighty subjects performed a one-dimensional compensatory tracking task for 55 one-minute trials. The subjects were divided into five separate groups and each group performed the task with a different exponential delay between the control input and the display, a dot of light on a cathode ray tube. The time constants for the exponential delays were 0.015 seconds, 0.150 seconds, 0.900 seconds, 2.100 seconds and 3.000 seconds, respectively. The results indicate that time-on-target scores decrease with increasing delay. For delays greater than 0.150 seconds, the decrease is linear. There is a sharper decrease in performance from 0.015 seconds delay to 0.150 seconds delay that for other portions of the function. Increased practice changes the level, but not the shape, of the total function. The effects of delay and learning were within the same range, indicating that a given level of system performance often can be achieved either by altering the delay or by training the operator. However, performance is maximized if delay is reduced and the operator is trained.

13. Levine, M., *Transfer of Tracking Performance as a Function of a Delay Between the Control and the Display*, WADC Technical Report 53-237, November 1953. AD 29 359.

Using a one-dimensional, compensatory tracking task, an investigation was made into the way tracking performance transfers as a function of changes in an exponential delay inserted between the operator's control and his display. The research was divided into two studies. The first investigated performance on a transfer task containing a 3.000 second exponential delay following training with the delays of either .015, .150, .900, 2.100, or 3.000 seconds in the system. The second investigated performance on a transfer task containing a delay of .015 seconds following training with delays of either .015, .900, or 3.000 seconds in the system. The results show that (a) when operators transfer to the longest delay, training with any of the shorter delays is equally efficient; (b) when operators transfer to the shortest delay, training efficiency decreases with decreasing similarity of the training and transfer situations. This suggests that the design engineer concerned with specifying the degree of simulation for instrument delays should consider the direction away from identity which lower fidelity will take. Shorter simulator delays would probably be permissible, whereas longer simulator delays should be viewed more critically. The results also suggest that training conditions should be somewhat easier than operational conditions for maximal training effectiveness. The fact, however, that the opposite conclusion has been confirmed in a number of previous studies renders a practical application inadvisable at present.

14. Miller, R. B., *A Method for Determining Human Engineering Design Requirements for Training Equipment*, WADC Technical Report 53-135, June 1953. AD 15 848.

This report summarizes and integrates three other technical reports, each of which plays a role in a procedure intended to determine the human behavioral requirements of complex training devices. These reports are Technical Reports: WADC-53-136, Handbook on Training and Training Equipment Design; WADC-53-137, A Method of Man-Machine Task Analysis; and WADC-53-138, Human Engineering Design Schedule for Training Equipment. The procedures described in these reports attempt to relate, in a systematic way, the contributions of psychology and psychologists to the design of training device and their optimal use. The following two phases which constitute the procedure are summarized: (1) a method for performing a behavioral analysis of man-machine tasks and (2) the application of human engineering design schedule to the planning or improvement of a training device. A brief description is given of the Handbook on Training and Training Equipment Design and its applicability to the procedures described above. These materials and procedures are designed for use by trained personnel in the preparation of recommendations concerning the design and use of complex training devices.

15. Miller, R. B., *Handbook on Training and Training Equipment Design*, WADC Technical Report 53-136, June 1953. AD 16 859.

This Handbook is intended to aid in preparing recommendations on the design and use of training equipment. As such, it permits cross referencing to a companion report, WADC Technical Report 53-138, Human Engineering Design Schedule for Training Equipment. The contents of the Handbook include learning and transfer theory, principles applicable to problems of training, and bibliographic references. One principal theme which is developed is that different kinds of tasks and different degrees of learning have different implications for transfer of training and the best form of presenting knowledge of results. Stages of learning are analyzed in detail, as are the variables in "knowledge of results." The principal sections are titled: I. Human Learning-An Overview; II. The Role of the Instructor in Training; III. The Trainer as a Demonstrator of Principles; IV. The Use of Knowledge of Results; V. The Problem of Simulation; VI. The Problem of Motivation; VII. Preparing the Specifications for a Training Device. The many problems indicated as requiring further research in the field of human learning and training suggest the importance of "programmatic" studies. These materials, in conjunction with WADC TR 53-137, A Method for Man-Machine Task Analysis, and WADC TR 53-135, A Method for Determining Human Engineering Design Requirements for Training Equipment, are designed for use by trained personnel.

16. Miller, R. B., *A Method for Man-Machine Task Analysis*, WADC Technical Report 53-137, June 1953. AD 15 291.

This report describes a systematic procedure for making a task analysis of the operator's job in any man-machine system. The quality and quantity standards defined for the man-machine system are analysed into constituent variables or functions. The operator is treated as part of the system's linkages from input to output functions. Information displayed to the operator is analyzed into essential discrimination requirements; control activations necessary to control the machine's outputs are analysed into component "effector" or response requirements. Other behaviors include "discrimination of response adequacy," "memory storage," "decisions," "coordinations," "anticipations," and "characteristic malpractices." Tasks are differentiated into discontinuous (procedural) and continuous (tracking). Formats for making the analysis are provided. The method, although of general applicability is specifically designed for use by trained specialists in planning for training and training equipment. Associated procedures are described in WADC Technical Reports 53-135, *A Method for Determining Human Engineering Design Requirements for Training Equipment;* 53-136, *Handbook on Training and Training Equipment Design;* and 53-138, *Human Engineering Design Schedule for Training Equipment.*

17. Miller, R. B., *Human Engineering Design Schedule for Training Equipment,* WADC Technical Report 53-138, June 1953. AD 14 768.

This report is an organization of several hundred considerations which, from a human factors standpoint, are important to the relevance and efficiency of training equipment. These considerations are applicable to a training device during initial planning, specification, prototype, or production model stages of trainer development. The items of the Design Schedule are grouped under the following main topics: 1. Designing a Trainer to Use as a Demonstrator of Principles; 2. Controls; 3. Displays; 4. Control-Display Interactions; 5. Programs; 6. Scoring and Error Analysis; 7. Motivation of the Student; 8. Conditions of Practice and Learning; 9. Facilities for the Instructor; 10. Research Data on the Task.

18. Montgomery, V. E., *Transfer of Training in Motor Learning as a Function of Distribution of Learning,* Journal of Experimental Psychology, 46: 440-444, 1953.

Transfer in a motor learning task was studied as a function of the distribution of practice on both the original and transfer task. The apparatus used for the Duncan-Underwood Star Discrimeter which requires performance of a steadiness test while simultaneously learning six perceptual-motor paired associates. The results indicated that transfer did not appear to be a function of the distribution of practice on the two tasks. As an explanation of these results it was indicated that possibly continuous practice results in temporary depression in performance but does not affect learning.

19. Morgan, R. L. and Eckstrand, G. A., *Effects of a Changed Environmental Context upon Performance of a Tracking Task,* WADC Technical Report 53-235, October 1953. AD 25 503.

The use of synthetic training equipment saves operational equipment and personnel. However, the availability of such equipment is influenced by its cost. This report represents an attempt to determine the training value of certain components which contribute to the cost of some synthetic training devices. Two groups, 20 male subjects each, were required to perform a two-dimensional tracking task in a complex situation (enclosed cockpit, red panel lights, helmet, engine noise, vibrator, etc.). Both groups had practiced the task one week earlier; however, one group had practiced in the complex situation while the other group had practiced in a more simple situation (open cockpit, ambient illumination, no helmet, no noise, no vibration, etc.). The results indicated that the complex environmental context depressed performance during practice; however, on the second day both groups performed equally well in the complex situation. Apparently, performance of a tracking task can be depressed by a complex context; however, if this task must be performed in such a complex situation, training in a more simple situation is as effective as training in the complex context.

The implication of these results for the design of training equipment is that the environmental stimuli which accompany the operational task need not always be incorporated into the training situation. However, some caution should be exercised prior to the application of these experimental findings to training situations where (a) adequate trainee motivation is unalterably dependent upon the context of the operational task and/or (b) where the task to be learned involves responses which are associated with particular environmental cues.

20. Rockway, M. R., *A Survey of Pilots' Opinions of the C-97 Flight Simulator*, WCRD Technical Note 53-38, April 1953. AD 62 899.

A questionnaire was administered to 30 rated pilots who had flown both the C-97 Flight Simulator and the C-97 airplane. The primary purpose of the survey was to determine the effect of certain control-loading deviations in the Simulator upon its training value. A number of questions were asked which referred to other aspects of the Simulator; therefore, the response data presented in this report may be considered as a limited evaluation of the Simulator as a whole.

ABSTRACTS FOR 1954

21. Ammons, R. B., *Knowledge of Performance: Survey of Literature, Some Possible Applications, and Suggested Experimentation,* WADC Technical Report 54-14, February 1954. AD 34 643.

This report represents a systematization of much of the currently available information concerning the influence of knowledge of performance on learning, performance and transfer of training. The results of a large number of studies are organized into eleven "empirical generalizations." Some possible applications of the generalizations to the design of training equipment are discussed and needed research studies, ranging from specific experiments to needed area programs, are indicated.

22. Ammons, R. B., Ammons, Carol H., and Morgan, R. L., *Movement Analysis of the Performance of a Simple Perceptual-Motor Task under Various Conditions,* WADC Technical Report 54-36, April 1954. Also in Journal of General Psychology, 58: 259-279, 1958. AD 34 306.

Techniques are available for the analysis of complex motor activities such as industrial assembly operations, and, the application of these techniques has contributed to the development of both improved methods of operation and more effective training programs. Despite their potential value, techniques have not been perfected, as yet, for the analysis of a continuous, skilled response. The present experiment represents an attempt to determine the value of motion pictures as a technique for recording, analyzing and classifying the movements which are made of changes in rotary pursuit performance due to duration of practice, introduction of rest periods, increased accuracy requirements, and increased rate requirements. Motion picture recordings were made, and all movements were classified into categories or types. An evaluation of the results indicated that they could be described simply in terms of changes of the movements from maladaptive and inaccurate to adaptive and accurate. It was proposed that the less effortful the particular conditions of the task, the more nearly performance will approach the optimum, with the less-adaptive movements dropping out. Also, it was suggested the the more effortful erroneous movements drop out more rapidly than the less effortful ones. It was concluded that motion picture recordings are a feasible technique for the analysis of at least rather simple, continuous responses. This technique should be useful in further investigations of skilled performance and in programs which are designed first to find, and then to teach, the optimally effective methods of performing certain continous tasks.

23. Ammons, R. B., Ammons, Carol H., and Morgan, R., *Transfer of Training in a Simple Motor Skill Along the Speed Dimension,* WADC Technical Report 53-498, March 1954, Also in *Perceptual and Motor Skills,* 6: 1956. AD 32 537.

The task used in this research was rotary pursuit at four different speeds. The speeds were assigned to the training and transfer periods in such a manner as to obtain all 16 possible combinations of speeds in the two periods. The 16 different combinations of speeds were presented under three different conditions of distribution of practice; thus, a total of 48 subgroups were employed in the experiment. It was found that the greater the speed of the task, the poorer the performance. And, in general, when the rate of the final task was equal to or lower than the rates of the training tasks, transfer of training was directly proportional to the similarity between the rates of the two tasks. However, when the speed requirements of the final task were quite great, all training conditions produced about the same time-on-target scores; but, in terms of percent transfer scores, the best training speed was slower than the final speed. These findings were independent of the distribution of practice conditions. The apparent inability of present transfer theories to account for these and other motor skills transfer phenomena is discussed. The limitations of current theories are attributed to the fact that they are based on research with tasks which do not vary in difficulty when inter-task similarity is manipulated by variations along a single task dimension.

24. Duncan, C. P., and Underwood, B. J., *Transfer of Training After 10 Days of Practice with One Task or With Varied Tasks,* WADC Technical Report 54-115, May 1954. AD 43 067.

Transfer among perceptual-motor paired-associate tasks was studied as a function of constant and varied training conditions. Over 10 days of training, one group practiced the same task every day (constant conditions), while training was varied for two other groups. One of these groups practiced 10 different tasks, one each day; the other group practiced the same task with the stimuli and responses re-paired each day. Following training, all groups were tested for transfer to four additional tasks. Transfer was tested over four days. Two of the four transfer tasks were used on each transfer day, so that half the subjects in each group were tested with one task, half with the other task, on each day. On the whole, varied training yielded superior transfer to constant training. However, this result was almost entirely due to the group trained with different tasks. Specifically, the different-tasks group performed significantly better than the constant-conditions group on both tasks on the first transfer day, on one task on the second transfer day, and during the initial half of practice on one task on the third transfer day. In contrast, the group trained by daily re-pairing the stimuli and responses of the same task exhibited better transfer than the constant-conditions group on only one occasion, namely, on one task on the first transfer day. The results were accounted for primarily in terms of learning to differentiate stimuli both within and among tasks and suppression of interference. These findings imply that training devices which provide a number of training tasks variations will yield greater initial transfer to operational equipment than training devices that provide only one training task. The results of the complete experimental program, of which this study is only a part, will reveal whether this conclusion is limited to the high levels of training and large number of training tasks used in this study. However, even the present findings do not imply that the greater transfer produced by a training device that provides a variety of tasks will always be sufficient to justify the cost of developing such a device. Even in those cases where superior transfer occurred after varied training, the duration of the superiority was at most three days. This is considerably less than the time that was spent in developing the training task variations.

25. Duncan, C. P. and Underwood, B. J., *Transfer of Training after Two Days of Practice with One Task or with Varied Tasks*, WADC Technical Report 54-381, September 1954. AD 54 619.

Transfer among perceptual-motor paired-associate tasks was studied as a function of constant and varied training conditions. Over two days of training, one group practiced the same task on both days (constant conditions), while training was varied for two other groups. One of these groups practiced 10 different tasks, five tasks each day; the other group practiced 10 different pairings of the stimuli and responses of the same task, five pairings each day. Following training, all groups were tested for transfer to three additional tasks. Neither method of varied training yielded transfer superior to constant training. This finding held without exception for all transfer tasks on all transfer days. A previously reported experiment had found superior initial transfer for varied training when training extended over 10 days, an interval which permitted each training task to be well mastered. In light of this, an attempt was made to account for the present results in terms of the lack of mastery of each training task and the attendant lack of skill in differentiating stimuli within and between tasks. The findings of this and the previous report imply that training devices which provide a number of training task variations may yield initially greater transfer to operational equipment than training devices which provide only one training task. However, it is also implied that it is worthwhile to design training task variations into training devices only if sufficient training time is available to obtain more than a small amount of mastery of each variation. Otherwise, there may be no advantage of varied training.

26. Duncan, C. P. and Underwood, B. J., *Transfer of Training after Five Days of Practice with One Task or with Varied Tasks*, WADC Technical Report 54-533, December 1954. AD 62 687.

Transfer among perceptual-motor paired-associate tasks was studied as a function of constant and varied training conditions. Over five days of training, one group practiced the same task every day (constant training), while training was varied for two other groups. One of these groups practiced 10 different tasks, two tasks each day; the other group practiced 10 different pairings of the stimuli and responses of the same task, two pairings each day. Following training, all groups were tested for transfer to four additional tasks. Neither method of varied training yielded transfer superior to constant training. There was no exception to this finding with any of the four transfer tasks on any of the transfer days. Two previously reported experiments have presented transfer data from groups for which the training period was respectively 10 days and two days. When training extended over 10 days, varied training produced better transfer than constant training, but not when only two days of training were given. It was suggested that the difference in results between these earlier studies was due to the difference in level of mastery attained on the training tasks, the level being considerably higher with 10 days than with two days of training. The results given in the present report show that the medium level of mastery of training tasks attained during the five-day training period also did not produce superior transfer for groups given varied training. The results of this and the earlier reports again imply that if training task variations are introduced into training devices, the number of such variations should be such as to permit attainment of a high level of mastery on each within the available training time. Otherwise, there may be no advantage in varied training.

27. Eckstrand, G. A., *A Human Factors Approach to the Design of Training Equipment,* Air Training Command Instructors Journal, 5: 145-151, 1954.

A systematic approach is described for making human factors recommendations on the design of training equipment. This approach involves (1) setting down in a systematic way the objectives of the training device and its proposed methods of use, (2) making detailed analyses of the tasks for which training is intended, and (3) formulating recommendations for a device to teach these tasks through a consideration of the characteristics of the trainee and relevant principles of learning and transfer of training.

28. Eckstrand, G. A. and Wickens, D. D., *Transfer of Perceptual Set,* Journal of Experimental Psychology, 47: 274-278, 1954.

This experiment was conducted to test the influence of perceptual biases produced by pretraining upon learning in a later situation. The task was a paired-associate type activity in which pressing one of four keys was determined by a visual stimulus. The visual stimuli contained two dimensions, form and color. Each

S learned four tasks -- two pretraining tasks which varied from group to group, a common task, and a test task in which only one of the two stimulus dimensions was present. The common task was one in which both dimensions were relevant to solution, and the question posed by the experiment was whether or not the pretraining would influence the dimension employed in learning this task. The operation of this bias was inferred by the performance on the final task in which only a single dimension was available to Ss. For a consonant group only one dimension, either form or color, was relevant to solution of the two pretraining tasks, and this same dimension which was relevant in the pretraining was absent in the test task. For a dissonant group, the dimension which was relevant in the pretraining was absent in the test tasks. For an ambiguous group both dimensions were relevant in the pretraining tasks. The influence of the pretraining was shown by the fact that on the test task the consonant group learned with greatest ease, the ambiguous was next, and the dissonant was the poorest.

29. Howe, R. M. and Schetzer, J. D., Final Report No. 1, *A Study of the Computer Section of Flight Simulators*, University of Michigan Report 2164-1-F, March 1954. AD 64 527.

This report summarizes the specific investigations undertaken in a three-part study program concerning: (1) method of computation used by the simulator manufacturers and by the computer industry in general; (2) flight equations used by the simulator manufacturers, the airframe manufacturers, and guided missile industry; and (3) performance of the trainers at the various bases, including engineering tests, study of maintenance problems, pilot complaints, etc. Results of these investigations are discussed and a number of specific recommendations for the computer sections of future training-type simulators are presented. The appendices include the development of aircraft equations of motion of discussion of aerodynamic forces and moments, and a brief introduction into the theory of electronic differential analyzers.

30. Howe, R. M., *A Study of the Computer Section of Flight Simulators*, University of Michigan Report 2164-6-F, October 1954. AD 60 155.

This report summarizes the results of a fifteen-month study of the computer section of training-type flight simulators. A previous report described the results of the first nine months of the study program. The previous report presents a number of specific recommendations growing out of the original study program. Work since then has led the author to emphasize further these recommendations which are included again in the present report. In addition, several recommendations with respect to specifications for dynamic performance of the trainer have been added in the present report.

31. Miller, R. B., *Psychological Considerations in the Design of Training Equipment*, WADC Technical Report 54-563, December 1954. AD 71 202.

A training device is a machine whose purpose is to teach job skills which will transfer to operational situations. As such, the human factors involved in efficient learning and transfer of training are considerations essential to economy and training value of trainer design. The report presents a number of considerations and recommendations for trainer design under the following topics: I. Some principle concepts in learning and transfer of learning; II. Problems of physical simulation; III. Stage of learning and degree of physical simulation; IV. Knowledge of results and scoring; V. Recording procedures; VI. Proficiency measurement; VII. The design of the instructor's station; VIII. The trainer as demonstrator of principles; IX. Outline of steps in designing a training device. This report is essentially a digest of previously published material by the author and by Dr. Alan D. Swain. It has been adapted for persons who may not have a professional background in psychology. The report is intended for those who participate in framing the requirements for training devices, designing them and, in lesser degree, for those who use them in training.

32. Morgan, R. L., Eckstrand, G. A., Rockway, M. R., and Newton, J. M., *Verbally Mediated Transfer as a Function of Order of Tasks*, WADC Technical Report 54-41, February 1954. AD 33 353.

One of the major problems in the design of training equipment is the simulation of the perceptual environment of the operational task to which control actions are cued. If the conditions under which a training environment can be made functionally equivalent to the operational situations were better understood, it might be possible to greatly simplify the design of certain training devices without sacrificing training value. The present study was designed to investigate one set of conditions (order of training tasks) affecting the occurrence of transfer of training resulting from a "learned" equivalence between pairs of stimuli in two tasks. Eight groups of subject, four "experimental" (E) and four "control" (C), received practice on three training tasks prior to being tested on the same final task. The training tasks were identical for all E groups, but the order in which they were experienced differed. Four orders of tasks were studied--positive transfer was predicted for two of the orders (E_1 and E_3), while zero transfer was predicted for the two (E_2 and E_4). When tested on the final task, significant amounts of positive transfer were displayed by E_1, E_2, and E_3, and "zero" transfer by E_4. An attempt was made to reconcile the results with Hull's theory of "mediated stimulus equivalence" by invoking a seemingly reasonable relationship between level of learning and "real" order of tasks.

33. Peterson, J. W., *Differential Analyzer Solution of the Linearized F-86D Equations*, University of Michigan Report 2164-4-T, July 1954. AD 87 032.

This report describes an investigation of the dynamic behavior of the F-86D aircraft by means of electronic differential analyzer solutions of the linearized equations of motion. The equations of motion used in this study are referred to body axis coordinates. These equations are linearized by assuming small perturbations which are uncoupled in such a way that longitudinal pitching motion is independent of lateral motion. The aerodynamic coefficients of the F-86D were substituted into these equations and airplane motion was then simulated on the electronic differential analyzer.

34. Rockway, M. R., *The Effect of Variations in Control-Display Ratio and Exponential Time Delay on Tracking Performance*, WADC Technical Report 54-618, December 1954. AD 62 763.

Previous investigations of the effects of control-display (C/D) time delay on the performance of continuous tracking systems have all demonstrated a decrease in system performance with increasing delay. A rational analysis of the joint effects of C/D gear ratio and exponential time delay suggests that the effects of increasing exponential delay depend upon the particular C/D ratio employed. The present study was designed to demonstrate this interaction between the effects of C/D ratio and exponential time delay on the performance of a two-dimensional tracking task. The experimental results verified the predicted interaction. More specifically, it was demonstrated that with the "highest" C/D ratio (where a given control input produced the smallest display change) increasing delay effected a monotonic degradation in system performance. But, with the "lowest" C/D ratio (where a given control input produced the largest display change) increasing delay effected a monotonic improvement in system performance. With an intermediate ratio system performance first increased and then decreased with increasing delay.

35. Swain, A. D., *Guide for the Design and Evaluation of the Instructor's Station in Training Equipment*, WADC Technical Report 54-564, December 1954. AD 71 203.

The purpose of this "Instructor's Station Guide" is twofold: (1) to provide procedures for the collection of data on the design of the instructor's station and (2) to provide a method to aid in the evaluation and design of existing or proposed instructor's stations. The contents of this report represent a human factors and systems analysis approach in answering the following questions: (1) What facilities and equipment are needed at the instructor's station for him to accomplish his mission? (2) How should these various components be designed for most efficient use? (3) How should the whole instructor's station be laid out to allow maximum instructor effectiveness? The report consists of the following: I-Introduction; II-Methodology; III-Equipment Design Considerations for the Instructor's Station; IV-Inventory of Trainee's Station Inputs and Outputs Relevant to the Instructor's Station; V-Examples of Human Engineering Inadequacies in the Design of the Instructor's Station; and VI-Two Questionnaires for Collecting Data on the Instructor's Station. This report is intended mainly for two audiences: (1) the specialist with a professional background in the theoretical and practical problems of human engineering, transfer of training; and the psychology of learning; and (2) the training specialist whose actual experience with the design and use of training programs and training devices has given him an awareness from a practical point of view of the qualifications sometimes necessary to general principles which must cover a large variety of circumstances.

ABSTRACTS FOR 1955

36. Rockway, M. R., *The Effect of Variations in Control-Display Ratio During Training on Transfer to a "High" Ratio*, WADC Technical Report 55-366, October 1955. AD 98 317.

One of the parameters of continuous control systems that appears to have relevance for transfer of training is control-display (C/D) ratio. The present study was designed to investigate the relationship between amount of transfer of a two-dimensional tracking skill and degree of physical similarity between training and test ratios. Each of the three groups received training using either a low, medium, or high C/D ratio. Following training, all groups were tested while using the high (i.e., least sensitive) ratio. The experimental results were as follows: (a) During training, tracking performance was a function of the C/D ratio employed. (b) All of the training ratios produced significant positive transfer to the test ratio. (c) Amount of transfer to the initial test trial was a function of the training ratio employed. However, differential transfer effects were very transitory, and by the second test trial differences among groups were no longer significant.

ABSTRACTS FOR 1956

37. Eckstrand, G. A. and Morgan, R. L., *The Influence of Training on the Tactual Discriminability of Knob Shapes,* WADC Technical Report 56-8, January 1956. AD 94 606.

To obtain data concerning the degree to which the tactual discriminability of a group of knob shapes could be improved by training, three matched groups of 20 subjects each were tested on a task which required that they discriminate tactually among four similar knob shapes. During the test, a knob shape was presented visually for about two seconds. Following this, the subject grasped an unseen knob attached to the top of a lever. The subject operated the lever if he believed the knob sampled tactually was the same as the one viewed, but he removed his hand if he believed it to be different. Each subject made two series of 24 such discriminations. Errors and the time required for each discrimination were recorded. Prior to performing this task a Control (C) Group was given no training, a Tactual-Name (T-N) Group learned to associate "names" with the feel of the knobs, and a Tactual (T) Group was given experience at feeling the knobs only. Group T-N was superior to Group C by both the time and errors criteria. Group T was superior to Group C in terms of the errors criterion only. All groups improved their performance from the first half to the second half of the discrimination trials. This improvement of knob discrimination by practice and training suggests that the designer of equipment for use by operators who will be highly practiced on that equipment often has greater freedom in the selection of (mutually discriminable) knob shapes than research with untrained subjects would indicate, or than would be appropriate for unpracticed operators. This finding highlights the important, but often neglected, fact that many of man's "capabilities and limitations" vary with the level of training and practice.

38. Howe, R. M. and Gilbert, E. J., *A New Resolving Method for Analog Computers,* WADC Technical Note 55-468, January 1956. AD 111 581.

A method of trigonometric resolution requiring only multipliers as nonlinear elements is presented for use with dc analog computers. The input to the system is θ, the time rate of change of the angle, and the outputs are sin θ and cos θ. The outputs are in the form of integrator output voltages or servo shaft angles (master pulses in the case of time division multipliers). Continuous angular travel through an indefinite number of angular revolutions is possible. The system is analyzed for accuracy and it is found that static accuracy is as good as the multiplier accuracy. It is shown that dynamic performance is not limited by multiplier dynamics when the angle θ is oscillating at small amplitudes. Use of the resolving method to compute Euler angles in a three-dimensional aircraft simulation is demonstrated.

39. Howe, R. M., *Coordinate Systems for Solving the Three Dimensional Flight Equations*, WADC Technical Note 55-747, June 1956. AD 111 582.

The choice of coordinate systems and the methods of coordinate resolution are extremely important in designing the computer section of flight simulators. In this report the six-degree-of-freedom flight equations are presented in the body-axis system, and the general equations for aerodynamic forces and moments are given. Next, the six-degree-of-freedom flight equations are rederived, using wind axes for the three translational degrees of freedom. Finally, the alternative use of body-axis Euler angles, wind-axis Euler angles, or direction cosines for coordinate transformations is discussed. It is concluded that the combined coordinate system which uses wind axes for translational and body axes for rotational equations is the best. Choice of coordinate transformation methods depends on the requirement of the simulation. Example computer circuits and recordings of computer solutions for the F-86D are presented.

40. Rockway, M. R., Morgan, R. L., and Eckstrand, G. A., *The Effect of Variations in Control-Display Ratio During Training on Transfer to a Low Ratio*, WADC Technical Report 56-10, October 1956. AD 110 640.

The present study was designed to investigate the relationship between amount of transfer of a two dimensional tracking skill and degree of physical similarity between training and test control-display (C/D) ratios. Each of three groups of subjects received training using one of three different C/D ratios. Following training all groups were tested while using the lowest (i.e., most sensitive) of the three ratios. The experimental results were as follows: (a) During training, tracking performance was a function of the C/D ratio employed. (b) Practice with all of the training ratios produced significant positive transfer to the test ratio. (c) The differences among the groups during the test period were not statistically significant.

ABSTRACTS FOR 1957

41. Duncan, C. P. and Underwood, B. J., *The Effect on Transfer of Varying Stimulation During Training*, WADC Technical Report 56-279, December 1957. AD 142 134.

The effects of both variation and amount of training on transfer among perceptual-motor paired-associate tasks were studied. Different groups of subjects were trained with 1, 2, 5, or 10 tasks (different sets of stimuli) for 2, 5, or 10 days. Some additional groups were trained 2, 5, or 10 days with 10 different repairings of the responses with the stimuli of a given set. After training, all groups were tested for transfer to three (some to four) new sets of stimuli. With amount of training constant, all degrees of varied training produced greater transfer than did either constant training or training with repairing, which were equally poor. Transfer increased both with amount and increase in variation in training. But, amount and variation did not interact. Differences between varied- and constant-training groups decreased considerably with successive transfer tests. Subjects trained with different sets of stimuli develop a general skill, probably observational or perceptual, which facilitates dealing with new stimuli. Thus, provision in training devices for varied training may enhance transfer, although this advantage should justify the expense.

42. Fox, P. L., *Design Study for Trainer, Visual Flight Attachment for Aircraft Flight Simulators*, WADC Technical Report 57-137 (I), September 1957. AD 216 438.

Design of a comprehensive visual display system to be attached to and used in conjunction with a fixed-based electronic flight simulator is described. The recommended design concept is based upon a rotary-sweep optical system capable of generating an extremely wide-angle presentation using narrow-angle techniques. Validity and feasibility of the system have been established through the engineering study program and experimental development conducted at Rheem-Philadelphia facilities. As the attachment of the system to the simulator will be accomplished by established techniques, this subject has not been discussed in detail as part of this study. The optical system is currently being subjected to detailed mathematical analysis by a competent optical engineering firm for confirmation of the first-order design. Subject to the results of this mathematical analysis, it has been concluded that Phase II of the proposed visual flight attachment system should be started. An outline of the work for this phase is included herewith.

43. Howe, R. M., *An Investigation of Flight Equation Requirements for Simulators of Aircraft Up to Mach 3.5*, WADC Technical Note 57-144, March 1957. AD 210 834.

This report summarizes the results of an investigation of the computer-section requirements of flight simulators for aircraft up to Mach 3.5 in performance capabilities. Included in the report are the flight equations which, it is felt, represent the best mechanization of the required computations. The source, expected range in value, effect on the aircraft response, and estimated tolerance requirements for the lateral and longitudinal stability derivatives are presented. The effect of inertia coupling terms is discussed, as well as recommendations ragarding which terms should be included in the simulator. A survey of the effect of aerodynamic heating and the probable simulator requirements which it may introduce is given. Finally, the expected dynamic performance range, both in regard to limiting velocities and accelerations, and in frequencies, is presented.

44. Howe, R. M., *An Investigation of the Relative Effect of Stability Derivatives on the Dynamic Characteristics of the F-100A*, WADC Technical Note 57-297, December 1957. AD 303 081.

This report summarizes the results of a computer study of the relative effect of stability derivatives on the dynamic characteristics of the F-100A. The purpose of the study is to indicate the tolerance requirements on stability derivatives necessary to insure adequate dynamic performance of training-type flight simulators. This in turn will allow a considerable reduction in the number of Mach number, altitude, lift-coefficient, and other function generators required in the solution of flight equations. The F-100A was chosen as a representative high-performance aircraft for which aerodynamic data are available.

45. Howe, R. M., *Final Report, Flight Simulator Theory Study*, WADC Technical Report 58-456, December 1957. AD 211 768.

This report describes the results of a three-year contract to study the computer section of flight simulators. The following general areas of study were included during the study period.
a. A study of the flight equations in order to determine the best coordinate system for solution of these equations. It was concluded

that a combined body axis and wind axis system is the most advantageous. b. The development of a new method of trigonometric resolution requiring only analog multiplier elements for mechanization. c. The study of analog computer component developments including three basic DC amplifier designs and a high speed servo multiplier employing film type potentiometers constructed in prototype form. d. An investigation of flight equation requirements for simulators of aircraft up to Mach 3.5 including the considerations of thermal heating effects on future simulator requirements. e. Preliminary study of standardized computer sections for solution of the flight equations. f. A preliminary study of flight equation requirements for helicopters and vertical takeoff and landing aircraft. g. Study of the relative effect of stability derivatives in determining the dynamic performance of high performance fighter aircraft. As a result of this study, tolerance requirements on stability derivatives are proposed.

46. Kopstein, F. F. and Morgan, R. L., *Human Factors Considerations in the Design Proposals for a Ballistic Missile Unit Proficiency System*, WADC Technical Note 57-352, December 1957. AD 142 040.

An outline is provided of human factors considerations for the design of unit proficiency systems (UPS). A UPS is the means by which crew skills are obtained and measured. Its characteristics depend upon the training and measurement job that must be accomplished. The job, in turn, depends on the system's demands for human performance (both manual and intellectual) and the initial capabilities of the personnel in the system. A major step in the procedure is a "task analysis". A "task analysis" is a systematic method for finding what trainees must do in their jobs. Personnel and training records predict initial trainee capability. Various means for achieving training objectives must be considered relative to their cost and efficiency. The UPS must be designed in accordance with the principles of human learning. The UPS must also give a valid and reliable indication of the overall status of unit proficiency.

47. Rockway, M. R., *Effects of Variations in Control Deadspace and Gain on Tracking Performance*, WADC Technical Report 57-326, September 1957. AD 118 347.

The present experiment was designed to investigate the effects of joint variations in control deadspace and gain on the efficiency of a first-order manual control system. Six experienced subjects performed on a one-dimensional compensatory tracking device using each of the twelve control conditions resulting from combining four levels of control deadspace and three levels of gain. The experimental results were as follows: (a) There was a systematic decrease in system performance with increasing control deadspace. (b) In general, performance with the low and medium control gains was superior to performance with the high gain. And, (c) the higher the control gain the greater the rate of decrease in system performance with increasing control deadspace.

ABSTRACTS FOR 1958

48. Duncan, C. P. "Transfer after Training with Single Versus Multiple Tasks," *Journal of Experimental Psychology*, 55: 63-72, 1958.

Transfer among perceptual-motor paired-associates tasks was studied as a function of two variables: degree of variation in training, which was defined in terms of the number of different sets of training stimuli, and amount of training. Different groups of Ss were trained with 1, 2, 5, 10 tasks (different sets of stimuli) for 2, 5, or 10 days (20 trials per day). Some other groups were trained for 2, 5, or 10 days with 10 different re-pairings of the responses with a single set of stimuli. Following training, all Ss were tested for transfer to two new sets of stimuli. The results were: (1) Among groups trained with different sets of stimuli, transfer increased as a direct function of degree of variation in training. In general, when total amount of training was equal, all degrees of varied training (2, 5, or 10 tasks) produced better transfer than constant training (1 task). (2) There was no interaction between degree of variation in training and amount of training; although transfer increased, up to a limit, as total training increased, the transfer superiority of varied over constant training was not significantly affected by changes in amount of training. (3) Groups trained by re-pairing the same stimuli, with the responses exhibited, as did groups trained with different sets of stimuli, considerable inter-task improvement during training, but showed no better transfer than constant training. It was suggested that these results may be best interpreted in terms of observational or perceptual processes.

49. Eisley, J. G., *An Investigation of the Relative Effect of Stability Derivatives on the Dynamic Characteristics of the F-106A*, WADC Technical Report 58-235, August 1958. AD 222 890.

This report summarizes the results of a computer study of the relative effect of stability derivatives on the dynamic characteristics of the F-106A. The purpose of the study is to indicate the tolerance requirements on stability derivatives necessary to insure adequate dynamic performance of training-type flight simulators. This in turn will allow a considerable reduction in the number of Mach number, altitude, lift coefficient, and other function generators required in the solution of the flight equations. The F-106A was chosen as representative of a high performance delta-wing type of aircraft for which aerodynamic data are available.

50. Fox, P. L., *Design Study for Trainer, Visual Flight Attachment for Aircraft Flight Simulators*, WADC Technical Report 57-137 (II), September 1958. AD 216 437.

In this report a study of landing trainer problems is carried through a supplementary phase to more adequately meet requirements in the extent of the pilot's field of view. Two interesting concepts for producing wide angle optics for use in visual simulation are discussed. The problem of illuminating transparencies at low angles of incidence is covered in some detail. Mechanical problems in map handling and lens manipulation are discussed.

51. Rockway, M. R., Morgan, R. L., and Eckstrand, G. A., "Effects of Variation in Control-Display Ratio and Amount of Original Practice on Transfer of Tracking Skill," *Symposium on Air Force Human Engineering, Personnel, and Training Research*, National Academy of Sciences, National Research Council, Washington, D.C., Publication 516, pp. 108-113, 1958.

A large number of operational systems for which training devices are designed--most notably, aircraft--require some form of manual tracking behavior of the human operator. One of the parameters of such systems that has received relatively little attention, from a transfer point of view, is control-display ratio. Control-display (C/D) ratio is generally defined as the amount of display change resulting from a given control input. Although changes in C/D ratio may be produced in a variety of ways, in the present context the experimental variation is analogous to a "mechanical" alteration of the C/D gear ratio. This paper reports a series of four independently run, but logically related experiments. Considered together they provide information concerning the effects of joint variation of C/D ratio and degree of original training on the transfer of tracking skill.

52. Rose, L., Bogan, C. J., and Heaviside, J. B., *Instrumentation of Flight Simulators*, WADC Technical Note 58-295, December 1958. AD 208 319.

The utilization of advanced computers without electromechanical components in advanced aircraft flight simulators requires the development of compatible simulated flight instruments. A modular system for the design of simulated instruments to operate directly from the output of such electronic computers has been developed, and preliminary designs for several typical instruments prepared. Emphasis has been placed on the development and test of several types of interchangeable servo actuators which may be utilized in the simulation of a whole range of flight instruments.

53. Samson, R. L. and Zahner, C. F., *Programming Techniques for Communication and Navigation Facilities*, WADC Technical Note 58-315, October 1958. AD 216 083.

The primary purpose of this project is to develop a programming technique that will reduce the time required to set up stations in a communication and navigation simulator. Several techniques for selecting stations on the basis of tuning or range, in varying degrees of automation, were considered. Two of these, Digital-Manual Station Programming and Digital-Automatic Receiver Programming, are recommended, the first for installation in existing simulators and the second for installation in future simulators.

54. Schohan, B., *Human Factors Recommendations for the Design of Cockpit Procedures Trainers*, WADC Technical Report 56-527, September 1958. AD 110 654.

The cockpit procedures trainer (CPT) appears to have promising potential as a training aid to teach pilots knowledge about aircraft systems, nomenclature and location of cockpit controls and displays, and procedures required to operate aircraft safely. This report is intended to aid design engineers by presenting first a discussion of the cockpit procedures trainer's role in training, and, second, a set of human engineering recommendations pertinent to the design of such trainers for fighter-type jet aircraft.

55. Sidowski, J. B., Morgan, R. L., and Eckstrand, G. A., "Influence of Task Complexity and Instructions Upon Simple and Discrimination Reaction Times," *Journal of Experimental Psychology*, 55: 163-166, 1958.

The present experiment investigated the influence of task complexity and instructions upon simple and discrimination RT. The standard procedure for measuring RT was used; however, after releasing the key S made one of three possible responses which differed in complexity. The three responses ranged from a simple finger withdrawal to a one-switch manipulation response, to a more complex three-switch response. Group I (N=24), with RT instructions, was told that this was a RT experiment and that E was primarily interested in measuring the fastest RT possible. Group II (N=24), with total movement time instructions, was told to direct attention to obtaining as fast a total movement time as possible (total movement time included both RT and switch manipulation times). Each S in both groups served under simple reaction and discrimination RT conditions. Analysis of the data showed no significant differences in RT between instructions. Discrimination conditions were found to produce longer RTs than did simple reaction conditions. Task complexity was also found to have a significant influence upon RT. The influence of task complexity was found to be a function of reaction type, discrimination or simple.

56. Smode, A. F., "Learning Performance in a Tracking Task Under Two Levels of Achievement Information Feedback," *Journal of Experimental Psychology*, 56: 297-304, 1958.

The present experiment was designed to provide an independent assessment of performance effects and learning effects in a compensatory tracking task as a function of the method used in providing cumulative information as to achievement level. With the exception of the procedural variable of information feedback (knowledge of achievement), the task was uniform for all Ss. A transfer of training design was employed, differentiating two basic conditions (high and low information feedback schedules) of the training phase into eight experimental subgroups in the transfer phase. On the transfer trials, one-half of the Ss continued to receive the same type of information imposed at the outset and one-half changed to the other schedule; one-half continued with the original target course while one-half transferred to a new target course equated for difficulty level. The high and low information feedback conditions differed in terms of the aggregate effect of the following three parameters: (a) the amount of information presented, (b) the sensory mode of presentation, and (c) the temporal characteristics of presentation.

57. Wickens, D. D. and Cotterman, T. E., *The Effect of Display Interruption on Transfer of Training Between Tasks of Different Control Sensitivity*, WADC Technical Report 57-548, March 1958. AD 131 027.

This study was designed to investigate the relationship between amount of transfer of skill in two-dimensional tracking and degree of physical similarity between training and test control sensitivity when the display was interrupted periodically during both training and test. Interrupting the display simulated the situation in which the operator is forced to divert his attention from tracking to perform other tasks. The general procedure was as follows. Groups of subjects were trained with one or the other of two control-display (C/D) ratios. Following training, all groups were tested while using the lower ratio (more sensitive control). In Experiment I, two groups were employed under conditions of interrupted display. In Experiment II, these groups were replicated and an additional two groups with non-interrupted tracking signals were employed. In both experiments, tracking performance during training was adversely affected by the higher sensitivity control and interruptions; but, while interruptions lowered tracking performance during test, none of the transferred groups were inferior to their control groups. Thus, tracking with an interrupted display apparently is not more sensitive to differential transfer effects attributable to differences in control sensitivity than is tracking with a continuous display, as used in previous studies. These results are compatible with the notion that the general features of a task are learned in early practice and only later, unique aspects are learned from which differential transfer effects may result.

ABSTRACTS FOR 1959

58. Askren, W. B., *Man Functions in Space Flight*. Presented to the Panel on Psychology of the Armed Forces--National Research Committee on Bio-Astronautics, in Washington, D.C., December 1959. AD 238-480.

The hypothetical activities of a 3-man crew of an earth-to-moon flight were analyzed with respect to some of the following subsystems: Navigation, flight control, energy management, environment control, secondary power management, communications, escape, reconnaissance, offense and defense. The following selection criteria were suggested: (1) sensory abilities, such as vision, hearing; (2) mental abilities such as general intelligence, computational skills, problem solving ability; (3) motor skills, such as tracking skill, response times; (4) tolerance to physiological stress, such as high g, heat, cold; and (5) adaption to new experiences (psychological stress) such as confinement, new food forms, and crew interaction.

59. Barling, H. B., Durant, J. R., Samson, R. L., and Wescott, H. W., *Programming Techniques for Communication and Navigation Facilities*, WADC Technical Report 59-792, October 1959. AD 231 260.

The design of a Digital-Automatic Receiver-Programming System is described. This system places data for ninety radio navigation stations on a magnetic drum and permits simulated radio navigation receivers to operate on this data based on frequency selection and range of the station. Audio station signals are recorded and made available from magnetic tapes. Another section of the report describes the design of the Engineering Model of the Digital-Manual Station Programmer which was attached to the ME-1 Trainer at the Aeronautical Accessories Laboratory.

60. Carr, W. J., *Self-Instructional Devices: A Review of Current Concepts*, WADC Technical Report 59-503, August 1959. AD 230 640.

A selective review of the literature on self-instructional devices is presented, with emphasis on those studies which provide for a functional analysis of such devices. Three major classes of variables which influence the effectiveness of learning by means of self-instructional devices are: characteristics of the device, characteristics of the program, and characteristics of the learner. Major attention is devoted to an analysis of the process of programming, or the arrangement of the materials to be learned in proper sequence which maximizes rate of learning and degree of retention. Discussion is focussed on a number of variables of which the process of programming might be a function. Some of these variables have not yet been subjected to experimental analysis. A working model is presented, based upon the familiar processes of conditioning.

61. Cotterman, T. E., *Task Classification: An Approach to Partially Ordering Information on Human Learning.* WADC Technical Note 58-374, January 1959. AD 210 716.

It is proposed that a task classification scheme(s) be developed in terms of which it is possible to sort all human learning tasks. Each task category would be set up in such a way that a specified set of common principles of learning referring to basic variables would operate essentially the same way in all task situations subsumed under it. In this way the actual and hypothesized effects of various basic and task variables and their interactions would be set forth. Task categories seem best defined in terms of general physical language with particular attention to the nature of the transformation of stimulus into response events, rather than in terms of inferred behavioral processes. The most practical method for developing the scheme probably would entail several persons intimately acquainted with the literature alternately hypothesizing schemes and sampling the more relevant literature as a check. Task classification would serve the general purpose of making information on human learning more usable and also result in a number of specific advantages both for research and application.

62. Hansen, O. K., Franks, P. E., and Modrick, J. A., *Nature and Use of the MAC-2 (Malfunction and Circuitry) Trainer,* WADC Technical Note 59-140, May 1959. AD 216 532.

Increased costs and complexity of equipment have forced consideration of using simulators for maintenance training. The MAC-2 trainer simulates the data flow of the MA-7A bombing-navigational system. It can be used to train the flight-line mechanic in the use of data flow knowledge and technical manuals through practice in trouble-shooting. It is also useful for performance evaluation. A brief history of this trainer is presented and its physical and functional characteristics are described. The specific objectives for the trainer and its advantages and limitations for attaining these objectives are discussed. In discussing the empirical basis for use of the trainer, the paucity of studies is emphasized. Modifications and research problem areas are suggested. It is concluded that the trainer has considerable face validity, but its specific purpose and the limited knowledge about its proper use should be considered in recommending this type of training equipment.

63. Hatch, R. S., *An Evaluation of the Effectiveness of a Self-Tutoring Approach Applied to Pilot Training,* WADC Technical Report 59-320, July 1959. AD 230 980.

This study concerns the problem of insuring ready recall of a large body of in-flight job information for Air Force pilots.

The effectiveness of a voluntary self-tutoring approach utilizing one type of "game appeal" device was examined. Two matched groups of Air Force pilots were pre-tested on their knowledge of instrument flying information. The device was then installed in the crew lounge of one of the groups. No device was available to the other group. After a two-month period both groups were post-tested. Despite the fact that minimal exposure to the machine occurred, players improved significantly on the criterion tests while non-players did not improve. Factors pertinent to the interpretation of the results and implications for further research were discussed.

64. Howe, R. M. and Lemm, R. G., *A Standardized Computer for Solving the Three-Dimensional Flight Equations*, WADC Technical Note 59-283, May 1959. AD 227 996.

The results of a study conducted for the purpose of standardizing the computer sections of flight simulators are presented in this document. The study is based upon data for airplane types ranging from high performance fighters to large transport aircraft in order to fulfill a requirement for simulation of all airplanes. A standard formulation and mechanization of the flight equations, except those for aerodynamic coefficients, is proposed for the simulation of all types of conventional aircraft. Since the relationships defining the aerodynamic coefficients differ considerably for different types of aircraft, no general standardization of the aerodynamic computations appears possible. However, a limited standardization of the longitudinal aerodynamics is presented. Separate computer layouts are given for the lateral aerodynamic computations for the aircraft studied as guides to the types and amounts of equipment required. Estimates of the computer component performance requirements are presented. It is concluded that the standardization of the computers will be more easily accomplished if aircraft manufacturers adopt standard forms for aerodynamic data presentation. Aeroelastic effects are found to be best simulated when aerodynamic data are presented as functions of dynamic pressure rather than altitude.

65. Johnson, L. L. and Christensen, K. K., *Study to Determine Methods of Simulating G Effects*, WADC Technical Note 58-314, August 1959. AD 211 849.

An experimental, variable-area, inflatable seat and shoulder harness with the necessary pneumatic actuators for the simulation of g force was fabricated on the basis of the system concept presented in WADC Technical Note 58-134. A special pneumatic controller was developed. The fabrication of the system and the subsequent testing is briefly outlined. The seat is described and illustrated by nine photographs. It is concluded that the system concept is feasible and that the simulated reactions and effects are quite accurate and realistic.

66. Knowles, W. B., *Automation and Personnel Requirements for Guided Missile Ground Support Functions*, WADC Technical Report 59-240, May 1959. AD 216 715.

This report summarizes an investigation of the high skill level requirements found in missile systems employing automatic electronic test and checkout equipment. Automation has not resulted in lowering manpower demands because (1) testing and maintenance requirements and objectives have not been systematically defined and (2) manual operations have not been completely described or programmed. A "maintenance system" design approach is outlined as a method for overcoming these deficiencies. Further research is recommended in development of techniques for evaluating the design of test logic, maintenance operations, and manual tasks.

67. Muckler, F. A., Nygaard, J. E., O'Kelly, L. I., and Williams, A. C., Jr., *Psychological Variables in the Design of Flight Simulators for Training*, WADC Technical Report 56-369, January 1959. AD 97 130.

In the design, construction, and utilization of synthetic training devices, two general problem areas have been frequently contrasted. The first of the areas is the degree of fidelity of physical simulation that may be achieved between the flight training device and the operational aircraft. This properly has been the concern of simulator design engineers, and it has been termed the problem of physical simulation. The second problem area is based on the ultimate criterion of any synthetic training device; the training value that results from the use of the device. This fundamentally is a psychological problem of transfer of training from the device to the aircraft that involves the psychological similarity between trainer and aircraft tasks. It is termed the problem of psychological simulation. The existing training research literature on flight trainers and simulators is evaluated, and a number of experimental programs are suggested. Motivational, instructional, and methodological variables are considered. Conventional theories of transfer of training are evaluated in terms of their predictive efficacy in the area of fidelity of psychological simulation.

68. Parker, J. F., Jr. and Fleishman, E. A., *Prediction of Advanced Levels of Proficiency in a Complex Tracking Task*, WADC Technical Report 59-255, December 1959. AD 236 907.

A group of 203 Air Force ROTC students was administered a large battery of printed and apparatus psychomotor reference tests from which 50 scores were taken. Following administration of the reference tests, subjects devoted 17 sessions distributed over a six week period to practice on a complex tracking task. Th matrix of intercorrelations among these scores was factor analyzed and 15 ability factors identified. An analysis then was conducted of the extent to which variation in performance in tracing at the different stages of practice could be accounted for in terms of the identified ability factors. The ability factors accounted for only a small portion of the variance in tracking performance. Hypotheses are offered concerning the selection of a different set of reference measures which might be more effective. The analyses of these data do indicate, however, that the prediction of terminal tracking proficiency is better accomplished through a set of external measures than through initial scores taken directly from the tracking task. Early proficiency on the task itself was unrelated to terminal proficiency.

69. Randle, R. J., Jr., *Vibrations in Helicopters: Training Considerations,* WADC Technical Note 59-61, March 1959. AD 212 314.

Helicopter instructor pilots were interviewed individually to analyze in detail the role that vibrations play in piloting helicopters. Information was gathered which indicated that vibrations are utilized as cues in both normal control and the detection and diagnosis of system malfunctions. Training considerations are discussed and recommendations made for a relatively gross simulation of each of the several classes of vibrations in a proposed helicopter instrument trainer.

70. Rockway, M. R. and Franks, P. E., *Effects of Variations in Control Backlash and Gain on Tracking Performance,* WADC Technical Report 58-553, January 1959. AD 250 537.

Six subjects performed a simulated aircraft tracking task using each of 12 control conditions resulting from combining four levels of control backlash and three levels of gain. The experimental finding demonstrated a significant interaction between the effects of backlash and gain on system performance. That is, there was a monotonic increase in system error with increasing backlash at all levels of gain. However, the higher the gain the greater the rate of increase. The implications of these results for the design of manual control systems were discussed briefly.

71. Schelhorn, A. E., *A Study of the Dynamic Response Characteristics of Flight Simulators,* WADC Technical Report 59-98, April 1959. AD 210 566.

The ability of a flight simulator to solve the characteristic flight equations of an aircraft is dependent upon the dynamic and small motion performance of the mechanical, electronic and servo elements of the simulator computer. One AC analog simulator and DC analog simulator were tested for small amplitude longitudinal dynamic response utilizing pulse, ramp, step, sinusoidal and square wave inputs. The purpose of the tests was to determine and analyze the over-all dynamic performance and the component performance of the AC and DC analog simulators and from the results of the testing, prepare a specification establishing requirements, tests and tolerances for dynamic response of future flight simulators. This report contains an analysis of the dynamic performance of the computers and various components utilized in the simulators tested. Representative copies of oscillograph records taken at the simulators, showing computer response to the various inputs are included. Requirements, tests and tolerances utilized in preparation of the specification are presented and discussed in the report.

ABSTRACTS FOR 1960

72. Cotterman, T. E., "Effects of Variation in Specificity of Knowledge of Results on the Improvement of a Perceptual Skill," NAS-USAF *Symposium of Personnel, Training, and Human Engineering*, G. Finch, Ed., Washington: NAS-NRC, 1960. Also published as WADC Technical Report 58-673, August 1960. AD 246 349.

Ninety male subjects estimated individually with respect to 120 stimulus photos how many degrees a 1/4 inch arrow would have to be turned to exactly parallel an adjacent arrowheaded line drawn across a 3 1/2 inch circle. The stimuli were presented for five seconds with ten seconds between and longer rest intervals separating sets of 24. Each set contained examples of the same 24 different stimuli in random order--correct answers ranging from 11 to 44 degrees and never being duplicated. Knowledge of results given orally after each estimation ranged in specificity from single right-wrong information to amount and direction of error information for five experimental groups. No knowledge was given a sixth control group. Differences in mean absolute and algebraic error per stimulus among groups reflect differences in specificity of knowledge given. It is concluded that knowledge of results increases the rate and level of learning to perform an absolute judgment of spatial extent and this effect is generally greater the more specific the knowledge.

73. Eckstrand, G. A. and Rockway, M. R., "The Role of Simulators for Spacecrew Training", Astronautics, 5: 38-39, 76, 79, 80, 1960.

This article is concerned with the role of the simulator in a space crew holding facility. The emphasis, however, is on one particular class of simulators. The discussion is not concerned with simulation facilities developed to solve engineering design and evaluation problems but with simulators which can be broadly designated as training simulators. These simulators are designed to assist in the development, maintenance and evaluation of human skills, knowledges and abilities.

74. Eckstrand, G. A., Rockway, M. R., Kopstein, F. F., and Morgan, R. L., *Teaching Machines in the Modern Military Organization*, WADD Technical Note 60-289, December 1960. AD 253 338.

The concept of "teaching machines" is explained and its relation to military training problems is made clear. Descriptions are given of the machines and techniques of Pressey, Skinner, Crowder, and Pask. Some emerging theoretical issues are briefly presented and discussed. Research intended to develop the potentialities of the "teaching machine" concept is described by reference to the current research program of the Behavioral Sciences Laboratory. The military uses of teaching machines and of the efforts needed to make their widespread use a reality are discussed.

75. Folley, J., Jr., Fairman, Jean B., and Jones, Edna, *A Survey of the Literature on Prediction of Air Force Personnel Requirements*, WADD Technical Report 60-493, July 1960. AD 244 539.

A survey of methods for predicting personnel requirements for future Air Force weapon systems is presented with abstracts of 121 unclassified, professional documents. Emphasis is placed on identifying procedures for deriving personnel requirements information and the supporting rationales. The current state of the art is evaluated and presented with implications for future research requirements. Conclusions from the study show that fairly thorough procedures exist for describing tasks and positions and for combining tasks into positions. However, no evidence was found of any systematic evaluation of this method. Estimating manpower requirements often has been done but only criticality of tasks has received little methodological attention. Most attention has been directed toward the rating of skill levels rather than toward any objective determination of skill requirements. One exception provides a seven-point scale of operationally defined performance levels. Like the other techniques found in this survey, this one has never been evaluated.

76. Franks, P. E. and Furnish, C. W., *Automated Maintenance: Theory, Practice, and Implications for Training*, WADD Technical Report 60-412, August 1960. AD 246-347.

Increasing complexity of electronic equipment, shorter reaction times and increased accuracy of weapon systems, relative neglect of design for maintainability, and unimproved quality of maintenance have resulted in the development of Automatic Check-Out Equipment (ACOE) to take over the most difficult tasks of maintenance. The need for ACOE, growth of the concept, factors affecting a workable concept, and characteristics of equipment test methods affecting utilization of ACOE are discussed. Functions of ACOE units are presented as paralleling basic maintenance activities. A typical ACOE approach, present status of the concept and its impact on other areas are reviewed. The effects on personnel requirements, motivation, logistics, cost, accuracy, and training are estimated and a proposed training program is summarized.

77. Gael, S. and Stackfleth, E. D., *A Data Reduction Technique Applied to the Development of Qualitative Personnel Requirements Information (QPRI) the Keysort Card System*, WADD Technical Note 60-133, May 1960. AD 243 681.

The feasibility of adapting the McBee Automatic Keysort System to Qualitative Personnel Requirements Information (QPRI) development was investigated using an existing Task Equipment Analysis to prepare a test model. Descriptive task statements were written on each card, and the following variables were coded and entered on the cards: Location, Task Newness, Ground Support

Equipment, Skill and Knowledge, Criticality, Task, Segment, and AFSC (Position). This preliminary investigation indicated that the McBee data reduction technique improves integration of human factors and hardware data making it possible to develop more effective QPRI reports in less time. In addition, a great deal of routine clerical work can be eliminated, and analyses which under the present system are prohibitive will be possible.

78. Greenwood, D. T., *An Extended Euler Angle Coordinate System for Use with All-Attitude Aircraft Simulators*, WADD Technical Report 60-372, August 1960. AD 249 068.

This report considers the problem of finding a suitable coordinate system for representing aircraft orientation. The new extended Euler angle system is compared with other coordinate systems (ordinary Euler angle system, reversed Euler angle system, and quaternion system), particularly with respect to the output variables and the amount of analog computer equipment required for simulator representation. The extended Euler angle system requires the most equipment but has the advantage of being an all-attitude system with outputs convenient for cockpit display.

79. Hood, P. D., Krum, R. L., O'Sullivan, F. J., Buckhout, R., Cave, R. T., Cotterman, T. E., and Rockway, M. R., *Conference on Integrated Aircrew Training* (March 1960), WADD Technical Report 60-320, July 1960. AD 240 688.

This report summarizes a conference on integrated aircrew training which was held to review information and stimulate discussion on the use of interconnected crew station simulators for aircrew training. The four presentations reviewed recent research on this topic and specific problems associated with the further research and use of integrated aircrew training. The early history and theory of integrated crew training, as well as recent research into this area were presented. Equipment problems associated with B-52 integrated training were presented from the operational viewpoint; and the role of integrated aircrew training in a flight training program was discussed.

80. Inaba, Kay, Wulff, J. J. and Kopstein, F. F., A Rational Method for Applying Behavioral Technology to Man-Machine System Design, *Air Force Human Engineering, Personnel, and Training Research*, NAS-NRC Publication 783, Glen Finch, Editor, pp. 65-72, 1960.

This report presents a concise description of how human performance can be designed into operational systems. Emphasis is on system performance, part of which can be accomplished by man. The "when" and "where" to use behavioral data in system design is also discussed.

81. Isakson, G. and Bunning, H., *A Study of Problems in Flight Simulation of VTOL Aircraft*, WADC Technical Note 59-305, February 1960. AD 233 441.

A study has been made of new problems involved in the simulation, for training purposes, of the flight of VTOL aircraft. The results of a literature survey and visits to establishments involved in VTOL aircraft research and development are described. Equations of motion are developed for a typical VTOL aircraft with a portion of its mass titling with respect to the remainder. Variously defined body axes are considered, and it is concluded that a set of axes parallel to the principal inertia axes of the fuselage and with origin at the center of gravity of the whole aircraft is advantageous. Gyroscopic moments are discussed. It is concluded that a body-axis coordinate system is desirable. Difficulties are encountered in the generation of aerodynamic data in near-hovering flight if angle of attack and angle of sideslip are the independent variables. In order to circumvent these difficulties, consideration is given to the generation of aerodynamic forces and moments directly as functions of velocity components in the direction of body axes. Results of a limited program of computations on the use of series expansions of these functions in terms of single-variable functions are presented and are found to indicate the feasibility of such a method. Consideration is also given to the use of two-variable function generators.

82. Kamm, L. J., Sherertz, P. C., and Steffen, L. E., *An Electronic Two-Variable Function Generator*, WADC Technical Report 59-546, March 1960. AD 236 964.

This report describes a transistorized bi-variable function generator developed by Convair-San Diego. The function is specified by the storage of 441 equally spaced ordinates. Bi-linear interpolation is employed to determine Z values between the stored ordinates. Each ordinate is specified by voltage, the voltages being obtained from a divider chain with outputs at each one percent step between plus and minus full scale. The independent variables, X and Y, select by an analog to digital converter and logic circuitry the four ordinates surrounding the point (x, y) and simultaneously develop in time division form, signals for bi-linear interpolation between the corner points. The voltages of the selected ordinates are switched by precision transistor switches into the interpolation circuits, where the output is generated. Function set-up is accomplished by patch cord connection of ordinate switches to voltage taps. Exclusive of power supplies and metering circuits, the function generator occupies about two cubic feet and requires about 60 watts. Substantial reduction in size would be practical in a production model.

83. Miller, R. B., *Task and Part-Task Trainers and Training*, WADD Technical Report 60-469, June 1960. AD 245 652.

Because enough simulators for sufficient and varied practice in job skills are rarely available, simpler devices are needed for training parts of tasks. In addition, learning total jobs one step at a time may be more efficient. Procedures for dividing total performance requirements into training segments lending themselves to distinctive types of trainers are described. Principal variables in the division are phase of learning and time sharing of activities. Risks of improper part-task training are detailed and principles for reducing such risks are proposed. Classes of trainers identified are: I. Familiarization Trainers, II. Instructed-Response Trainers, and III. Automated Skill Trainers. Essential training and human engineering variables are described for each of the above classes of devices. Potentialities of the Class II device are emphasized.

84. Pinkernell, H., *Flight Path Recorder,* WADD Technical Note 60-4, January 1960. AD 243 928.

This report presents the results of the study that has been conducted to conceive and evaluate a system which will produce a series of flight paths of airborne vehicles whose input information is in the form of spherical coordinates. The various subsystems described herein, toward which these evaluation studies were directed, include coordinate transformation computation, storage tube techniques for the generation of flight paths, permanent storage methods, and display techniques utilizing projection and optical principles. Devices that identify and supply a direction indication for each flight path, and equipments to automate various functions in the total system were also investigated and evaluated. As a result of conferences with the Aeronautical Chart Information Center and with WADD, the Lambert conformal projection has been chosen for all maps except those depicting the polar areas. This system will provide world wide map coverage in a series of approximately 50 maps, having scale factors ranging from one in ten million to one in one-half million. A description of a flight path recording system based on the foregoing evaluations and investigations is included in this report. This basic system is then used as a basis for comparisons with other less complex systems that perform the same basic functions, but with variations in either accuracy or flexibility.

85. Rasmussen, S. B., *Analog Function Generation,* WADC Technical Report 59-439, February 1960. AD 233 602.

The primary purpose of the function generator described in this report is to generate a variable $z=f\ (x,y)$ as a function of two independent variables, x and y, where the output variable (z) as well as the input variables (x,y) are represented as analog d-c voltages. The function is stored in the manner of a square 21 x 21 matrix consisting of discrete voltages which are manually selected by making appropriate patch board connections to a precision transformer powered by a 100-cps square wave source. To interpolate between these voltages, they are applied to a ceramic resistance film at discrete points placed in equidistant rows and columns. The connections to the resistance film are made through flexible pigtails. A specially developed rectilinear servomechanism is used to position the film element so that its displacement is proportional to one of the input variables (y). Thus, with the proper potentials applied to the resistance film, the output voltage of the sliding contact equals z=f (x,y). In order to have the output variable represented by a d-c voltage, a scheme for synchronous demodulation is incorporated. The equipment is capable of 1.0% accuracy, 5 cps frequency response, required 100 watts of power, and is adaptable for generating many other types of function.

86. Stave, A. M., *Human Factors in Design of Automatic Programming and Recording for Trainers (AN/ASG-15-T1 Fire Control System Trainer)*, WADD Technical Report 60-558, August 1960. AD 243 967.

This report describes the Fire Control System Trainer, AN/ASG 15-T1 for B-52 gunners. This trainer features an automatic recording system and an automatic programming system. The parameters used in recording the student performance are: reaction times, critical target ranges, and a weighted error score displayed in numerical form. Automatic programming is accomplished through the use of motion picture films which control a television presentation to the student. Automatic recording is accomplished through use of a series of timing devices. The ASG-15 demonstrates the sophistication that can be achieved with relatively simple and inexpensive training equipment.

87. Behavioral Sciences Laboratory. *Uses of Task Analysis in Deriving Training and Training Equipment Requirements*, WADD Technical Report 60-593, December 1960. AD 252 946.

The requirements for and uses of task information in developing requirements for training equipment are discussed in a series of seven papers by the human factors subcontractors involved in the development of three complex electronic reconnaissance systems. The papers deal with the purposes, content, sources, and recording of task information. They cover the uses of task analysis information in establishing of training requirements, selecting training equipment, and developing proficiency measures. A final paper describes, in detail, the approach taken on these issues with the AN/ULD-1 system.

ABSTRACTS FOR 1961

88. Askren, W. B., "Some Implications of Air Force Training Research for Industry," paper presented at the meeting of the American Psychological Association, New York, September 1961, *American Psychologist,* Vol. 16, No. 7, 1961.

An analysis of the titles of Air Force training research studies suggested that the research did not have direct implication for industrial training, as over half of the titles described studies of a basic nature dealing primarily with principles of learning, and the next largest category of titles were concerned with training equipment design. However, an examination of the content of the research studies, and a study of applied Air Force training activities resulted in identification of a number of training concepts useful to industrial personnel. These concepts are: (1) the use of system analysis and task analysis methods will result in an accurate determination of training needs; (2) the use of job analysis and trainee qualifications analysis information in a subtractive process will result in an accurate determination of training course content; (3) over learning is mandatory in teaching skilled tasks that require near-perfection performance; (4) team training is a valuable method of teaching group interaction skills; (5) mechanical aids, such self-tutoring devices can provide a valuable assist to industrial training programs; (6) simulation techniques that involve computer programming of events can provide realistic off-the-job training exercises; (7) Computer programmed training exercises will provide quantitative data useful in measuring trainee performance. Concept 2., "The use of job analysis and trainee qualifications analysis information...in determination of training course content" was described in detail using a hypothetical machine shop job as the illustrative medium. It was concluded that Air Force training research will have more value to the industry of tomorrow, which will be the industry of automation, the industry of more complex man-machine systems. As this time approaches the difference between industrial training and Air Force training will become less.

89. Beer, M., Jayson, R. M., Carter, V. E. and Kresse, F. H., *Survey of Escape Training in the Air Force*, WADD Technical Report 60-792, March 1961. AD 255 917.

The present state of Air Force ejection seat training was studied and its contribution to the overall ejection problem was considered. Relevant information was obtained from the literature on ejection training, training films, aircrew personnel, aircrew personnel who have ejected, accident statistics, and escape training instructors. The results showed that ejection training is inadequate in content and frequency. There is a lack of standardized regular training programs. Furthermore, training media, such as ejection seat trainers and films, leave much to be desired in both quantity and quality. Even more important, training to reduce fear of and anxiety about ejection is needed. In general, aircrew personnel "know" when to eject, but hesitate to take action because of an inadequate knowledge of procedures and an anxiety produced by unfamiliarity with the ejection experience. Ejection training in the Air Force is inadequate and needs to be improved.

90. Buddenhagen, T. F. and Wolpin, M. P., *A Study of Visual Simulation Techniques for Astronautical Flight Training*, WADD Technical Report 60-756, March 1961. AD 260 093.

A study was made of the engineering requirements for visual simulation in astronautical flight training and of the basic techniques available to accomplish such simulation. An evaluation of the potentialities of the various techniques led to the choice of closed circuit television as an image transfer technique. A preliminary design concept using this technique was formulated to determine the areas in which development work will be required prior to the design of a complete simulator. This report includes a compilation of applicable techniques, a determination of the probable visual environment of space, and an investigation of a method to predict the perceptual fidelity achieved by various simulation techniques as an aid in optimizing the training value of a simulator.

91. Bunning, H, *Flight Simulation of Orbital and Reentry Vehicles: III. Aerodynamics Information Required for Six Degrees of Freedom Simulation*, ASD Technical Report 61-171 (III), December 1961. AD 282 995.

A survey of the aerodynamic information required for a simulator for a glide reentry vehicle is presented. Various phases of the flight are considered: Hypersonic reentry, hypersonic-supersonic glide, and supersonic-transonic-subsonic approach and landing. Accuracy requirements and origin of aerodynamic information are briefly discussed. Aerodynamic parameters are defined, and the dependency of aerodynamic coefficients on these parameters is outlined. Special emphasis is placed on a technique for generating functions of two or three independent variables and some sample calculations are presented.

92. Demaree, R. G., *Development of Training Equipment Planning Information*, ASD Technical Report 61-533, October 1961. AD 267 326.

In the development of Air Force Systems, the timely procurement and delivery of training equipment is essential. Many human factors and engineering considerations enter into the determination as to what items of training equipment will best serve the purposes of a particular system. This report attempts to take proper account of both the engineering and human factors considerations but places special emphasis upon the latter. The report is divided into seven sections entitled: Introduction, An Overview of Training Equipment Planning, Training Functions for Various Types of Training Equipment, Training Equipment Utilization, Training Equipment Effectiveness Characteristics, Training Equipment Costs, and TEPI Development.

The appendices cover; Explanation of Terms, The Personnel Subsystem and Its Elements, and a Selected Bibliography. Liberal use is made of graphic and tabular presentation to illustrate the principles presented.

93. Eckstrand, G. A. and Rockway, M. R., *Spacecrew Training: A Review of Progress and Prospects*, ASD Technical Report 61-721. December 1961. AD 274 190.

This report reviews current progress and future prospects in the field of spacecrew training. Descriptions of all current astronaut training programs are presented, and a number of general conclusions with reference to such training are drawn, based upon the manned space operations which have been conducted to date. In addition to the actual experience which has been gained in training spacecrew personnel, a review is presented of recently completed and current research which is directly relevant to this problem. Several areas in which research should be accelerated are identified.

94. Fogarty, L. E. and Howe, R. M., *Flight Simulation of Orbital and Reentry Vehicles: Part II. A Modified Flight Path Axis System for Solving the Six-Degree-of-Freedom Flight Equations*, ASD Technical Report 61-171 (II) October 1961. AD 269 283.

The three translational and three rotational equilibrium equations for an orbital vehicle subject to aerodynamic and jet reaction forces are derived using a modified flight-path axis system for the translational equations. The dependent variables of the system are horizontal velocity component, vertical velocity component, and flight-path heading angle. The resulting equations are shown to have advantages for computer mechanization over alternative axis systems for the translation equations. Complete equations for determining vehicle orientation, instantaneous latitude and longitude, angle of attack, angle of sideslip, aerodynamic forces and moments, etc., are presented. Modifications in the translational equations which allow direct solution by an analog computer are also given. Analog computer mechanization of these equations in both real and fast time is described, including novel technique for division which preserves favorable multiplier scaling. Specific machine results are presented which demonstrate accurate solution of close-satellite trajectories, including reentry from satellite altitudes to sea level. With no change in circuit or scaling the same computer mechanization yields zero-drag orbits which close within several hundred feet of altitude.

95. Folley, J. D., Jr., *Research Problems in the Design of Performance Aids*, ASD Technical Report 61-548, October 1961. AD 270 866.

Performance aids are items of auxiliary equipment or documents provided to facilitate on-the-job performance by humans in man-machine systems. They may be included in the system at any stage of development, with their potential contribution greater if they are considered early, diminishing as their inclusion is delayed to later stages of system development. A number of research problems identified during preparation of a procedure for incorporating performance aids into systems are presented under five major headings that denote the logical steps involved in designing aids and integrating them into a system. Few of the issues and problems are new. Viewing them from the point of regard of performance aids, however, may provide a new emphasis and a new approach to the problems. Preliminary ideas of approaches to some of the problems are provided. The point is made that programmatic, multivariate research studies are needed to make significant progress on the problems.

96. Folley, J. D., Jr. and Munger, Sara J., *A Review of the Literature on Design of Informational Job Performance Aids*, ASD Technical Report 61-549, October 1961. AD 270 867.

Performance aids are items of auxiliary equipment or documents provided to enhance on-the-job performance. Military reports and psychological journals were surveyed to identify reports of research on the design of performance aids. Most research on this topic was done prior to 1958. No studies attempted to identify the significant variables in this design of aids. The preponderance of the work was concerned with developing and trying sample aids. Several studies indicated that procedural aids can facilitate trouble-shooting performance. The extent to which other kinds of aids can facilitate performance of other kinds of tasks is unknown. An annotated bibliography is presented.

97. Folley, J. D., Jr., *A Preliminary Procedure for Systematically Designing Performance Aids*, ASD Technical Report 61-550, October 1961. AD 270 868.

Performance aids are devices or documents that facilitate task performance by humans in a system. These supplementary aids to performance can enhance the overall quality of a system by assisting in achievement of more nearly optimal man-machine function allocation, by reducing the level of requirements on selection, training, and manning, or by raising on-the-job performance levels. Four steps in the design of performance aids are presented: (1) identification of task elements for which aids should be provided; (2) determination of appropriate functional characteristics of aids for these task elements; (3) specification of the physical design characteristics of the aids to carry out the functions; and (4) evaluation, modification, and updating of the aids. Supplementary data on capabilities of performance aids are presented for use with the procedure. The procedure is untried and of necessity uses stopgap solutions to problems on which much research or development is needed.

98. Gael, S. and Reed, L. E., *Personnel Equipment Data: Concept and Content*, ASD Technical Report 61-739, December 1961. AD 273 890.

Consideration of the degree of uncertainty surrounding Personnel-Equipment Data (PED), one of the Personnel Subsystem Elements (PSS), led to the present attempt to empirically define the content of PED, and to identify requirements contained in Military Specifications and related documents which can and often do, generate unnecessary duplicative effort. Eighteen documents deemed relevant to the study were scrutinized, and requirements calling for the submittal of data were extracted. A list of these requirements and their locations is presented. The amount of duplication tending to bring about redundant work effort was less than anticipated, but sufficient to provoke a good deal of concern. A few sources of unnecessary duplication of effort are discussed, and suggestions which can help eliminate duplication are presented.

99. Hart, E. M., *Effects of Outer-Space Environment Important to Simulation of Space Vehicles*, ASD Technical Report 61-201, August 1961. AD 269 014.

The results of a literature survey undertaken to define the effects of the outer-space environment to the simulation of space vehicles are presented. The discussion is general, having not been constrained by the inclusion of specific vehicles or trajectories. Only the natural environment of space is considered and the survey is limited to the solar system with particular emphasis on the region in the near vicinity of the earth-moon system and at heights greater than 80 kilometers above the earth's surface. To specify those effects that need to be incorporated into a space training simulator, the exterior environment, its effects on the vehicle and crew, and the malfunctions that may result must be determined. These subjects are treated, along with a consideration of the adequacy of the existing data in the study. Recommendations for further study are presented.

100. Isakson, G., *Flight Simulation of Orbital and Reentry Vehicles: Part I. Development of Equations of Motion in Six Degrees of Freedom*, ASD Technical Report 61-171 (I), October 1961. AD 269 282.

Equations governing the motion of a lifting reentry vehicle in six degrees of freedom are developed for simulation purposes. Effects of earth rotation, earth oblateness and wind velocity are included. The rotational equations are conventional equations involving angular rates referred to body axes. Two difference formulations of the translational equations are presented, using different coordinate systems. One involves spherical coordinates referred to the equatorial plane of the rotating earth; the other involves spherical coordinates referred to a nominal trajectory plane fixed with respect to inertial axes. The former has the advantage that earth rotation and oblateness are taken into account more simply, but an indeterminacy is encountered in the event of flight over a pole. The latter formulation eliminates this indeterminacy but is otherwise more complex. It is concluded that the equations developed are suitable for digital or hybrid analog-digital computation, but that accuracy requirements would be excessive for analog computation exclusively. An alternative formulation, suitable for analog computation, is presented in Part II of the present series.

101. Isakson, G., *Flight Simulation of Orbital and Re-Entry Vehicles: IV. A Study of Earth Oblateness Effects and Characteristic Oscillatory Motions of a Lifting Reentry Vehicle*, ASD Technical Report 61-171 (IV), December 1961. AD 274 251.

The present report is concerned with two distinct aspects of the simulation problem for a lifting reentry vehicle. The first relates to the effects of earth oblateness on the flight path of such a vehicle. The effects of oblateness of the gravity field on the orbital motion of a satellite are surveyed and are found to be small for a single orbit, probably sufficiently small to be neglected in a simulation for training purposes. Some of these effects are cumulative and would become substantial in a flight of long duration. The effects of oblateness of the earth's surface and atmosphere on the reentry trajectory are studied independently of the gravity oblateness effects. Typical trajectories are computed for the case of nonrotating effects. Typical trajectories are computed for the case of nonrotating earth. Under the most extreme conditions, there is found to be a change in the range of 690 nautical miles for a nominal once-around' flight. The second aspect relates to the characteristic oscillatory motion of the vehicle during reentry. The pertinent literature on this topic is surveyed. Approximate expressions for the period of the characteristic long-period and short-period oscillations are presented.

102. Kopstein, F. F. and Shillestad, Isabel J., *A Survey of Auto-Instruction Devices*, ASD Technical Report 61-414, September 1961. AD 268 223.

This report summarizes the state of the art of auto-instruction and teaching devices and catalogs instructional devices to April 1961, in the interest of suggesting possible applications to local training or educational problems. The first section briefly reviews what auto-instruction is, whether it is an entirely new concept, its practical benefits, auto-instruction terminology, programs and devices, current programming formats, evaluating a program, and discusses prospects for the future of auto-instruction. The second section catalogs and describes all major current auto-instructional devices: Skinner machines, Pressey machines, Crowder technique, self-organizing systems, audio-visual machines, digital computers as teaching machines, and miscellaneous devices. A list of teaching machine patents is appended.

103. Lohrenz, C. A. and Zymet, B. L., *Synthesized Equipment for Ground Based Radar Systems: I. Radar Operator Training the Man, The Machine and the Simulator*, ASD Technical Report 61-411 (I), October 1961. AD 269 962.

The requirements of training for the ground based radar operator are analyzed by looking at the man and the training structure, the machine he operates, and last, the training devices used by instructor personnel in training the operator to perform his task. The Air Force speciality codes for the radar career field are included for those that are not familiar with them. Various radar types including search, precision, height finding and tacking, are reviewed as to their applicability in the more complex radar situations. A hybrid synthetic technique capable of more complete radar environment simulation is promulgated providing the Air Force with a tool for faster and more adequate radar operator training. Furthermore, the design is flexible allowing easy modification or additions as the need for even more sophisticated training systems arises.

104. Losee, J. E., Payfer, G. E., Frahm, W. F., and Eisenberg, B., *Methods for Computing Manpower Requirements for Weapon Systems Under Development*, ASD Technical Report 61-361, August 1961. AD 264 435.

A method has been developed for an accurate and comprehensive forecasting of manpower requirements for new weapon systems. The manning estimate is developed through a series of integrated steps leading to position descriptions and numbers of men required. Early training information is obtained directly from Task Equipment Analyses; information covering ground support and other equipment, spares and consumables is obtained as a by-product. Plans are presented for an approximation of the effect of environment upon manning requirements for the determination of manhours required for work of a type not amenable to direct task analysis, and for the estimation of maintenance activity frequency rates.

105. Marks, M. R., *A Data Organizational Model for the Personnel Subsystem*, ASD Technical Report 61-447, September 1961. AD 266 320.

The need for organizing Personnel-Equipment Data (PED) for any system is discussed; development considerations and constraints for such a model are described. It is concluded that a model which organizes all system basic data will serve for PED as well. A model is adopted which represents an analogue of the system itself, the model acting as an index or table of contents to the data. A hierarchical organization of system levels is defined and a locator-code symbol is devised to be the address and description of type for any particular datum. Examples are given of the application of the model to various types of system. Problems in implementing the model in any system are discussed. Appendices representing categories applicable to the basic data of any system are presented. There is some discussion of possible mechanization of data storage and retrieval in connection with the use of the model.

106. Marks, M. R., *Development of Human Proficiency and Performance Measures for Weapon Systems Testing*, ASD Technical Report 61-733, December 1961. AD 272 975.

Methods for evaluating human performance are discussed and compared for validity, reliability, objectivity, standardization, and economy. Personnel subsystem test development constraints are considered and methods are proposed for the construction, scoring, administration and standardization of measurement instruments. Appendices are included which exhibit sample content, sample computation and definitions of terms of the Personnel Subsystem.

107. Muckler, F. A., Obermayer, R. W., Hanlon, W. H., Serio, F. P., and Rockway, M. R., *Transfer of Training with Simulated Aircraft Dynamics: I. Variations in Period and Damping of the Phugoid Response*, WADD Technical Report 60-615 (I), December 1961. AD 278 627.

This report is the first in a series dealing with transfer of training skill as a function of variations in simulated aircraft longitudinal dynamics. The research is pertinent to the question of how accurately the aerospacecraft simulator must represent the dynamic flight responses of the aerospacecraft in order to assure optimum transfer of training. Subjects performed one-dimensional tracking of a slow, low-amplitude sinewave input. The control dynamics of major concern were long-period oscillatory transients (the phugoid response). Independent variations were made in the period and damping of the phugoid response. Also, pilot and non-pilot performance was compared. During the training trails, tracking performance was poorer the longer the period of phugoid response. For the slowest period (71 seconds), tracking of performance was often below that which could have been obtained with no movement of the operator's control. Wide variations in damping had no differential effect on tracking performance. Pilots and non-pilots did not differ in tracking performance during the training trails. Performance on the transfer trails was considerably influenced by the relationship between the period of the phugoid response in the training task and the period of the phugoid response in the transfer task. When the period of the phugoid response during training was shorter or longer than that for the transfer task, performance was inferior to when it was the same. Variations in damping did not differentially influence transfer of training.

108. Muckler, F. A., Obermayer, R. W., Hanlon, W. H., and Serio, F. P., *Transfer of Training with Simulated Aircraft Dynamics: II. Variations in Control Gain and Phugoid Characteristics*, WADD Technical Report 60-615 (II), December 1961. AD 278 613.

This report is the second in a series dealing with transfer of training as a function of simulated aircraft longitudinal dynamics. Subjects performed single dimension compensatory tracking with long period (phugoid) oscillatory control system dynamics. Three experiments are reported dealing with variations in control gain. Increasing control gain resulted in equally high training and transfer performance for all oscillatory transient conditions studied, but at a lower gain level, significant differences were found. If rate of onset of the transient conditions were not equated by adjusting control gain, significant negative relative transfer of training was elicited. Equalization of rate of onset, however, substantially reduced training performance differences and eliminated negative transfer effects.

109. Muckler, F. A., Obermayer, R. W., Hanlon, W. H., and Serio, F. P., *Transfer of Training with Simulated Aircraft Dynamics: III. Variations in Course Complexity and Amplitude*, WADD Technical Report 60-615, (III), December 1961. AD 278 623.

This report is the third in a series of experiments dealing with transfer of training as a function of simulated aircraft longitudinal dynamics. Subjects performed single dimension compensatory tracking with long period (phugoid) oscillatory control system dynamics. Two experiments are reported dealing with changes in course complexity and amplitude of the experimental stimulus forcing function. Increasing course complexity was found to substantially affect transfer of training, but not training performance. Increasing course amplitude markedly affected training performance, but not transfer of training. In general, transfer effects were greater from less difficult to more difficult task conditions. These results are superficially inconsistent with previously reported studies. However, many of the phenomena are directly attributable to the presence of complex system dynamics which were absent in prior studies.

110. Naylor, J. C. and Briggs, G. E., *Long-Term Retention of Learned Skills: A Review of the Literature*, ASD Technical Report 61-390, August 1961. AD 267 043.

The ability to retain a learned skill or habit over extended time periods is a problem which has, as yet, not been too thoroughly explored. Reviewing those articles which seem to relate either directly or peripherally to long-term retention of learned motor behavior indicates that the number of variables of possible importance is quite large, and that in general only limited research has been conducted with any one of these given variables. The variables appear to fall into four general classes: those dealing with the type of task, those concerned with learning parameters, those concerned with retention interval parameters, and those concerned with recall parameters. Research under each category is reviewed and commented on, and suggestions are made that certain variables (such as task "organization" and the scoring method used) should be considered as key variables in any research program dealing with the long-term retention of skills.

111. Parker, J. F., Jr. and Downs, Judith E., *Selection of Training Media*, ASD Technical Report 61-473, September 1961. AD 271 483.

The selection of training media in support of military training programs represents an important area of concern. Training equipment exercises considerable influence on the way in which training programs are conducted, upon their effectiveness in accomplishing objectives, and upon the total cost of the program. This report is designed to assist a training analyst faced with the problem of selecting specific training aids and devices to be used in support of the development of the personnel subsystem of a military system. The translation of statements of desired personnel performances and capabilities, as presented in Qualitative and Quantitative Personnel Requirements Information and task analysis documents, into training objectives is discussed. The effectiveness of various training media in meeting specific training objectives is indicated and justified in terms of available objective evidence. An example is presented illustrating the manner in which training media are selected in support of a typical Air Force operator position.

112. Schwartz, N. F., *A Game Theory Apparatus for Psychological Research*, ASD Technical Report 61-239, July 1961. AD 265 389.

This report describes an electrical apparatus designed to facilitate psychological research in games of strategy for game matrices no larger than 3 x 3. The description includes an operational procedure and an explanation of the circuitry with an accompanying photograph of the equipment and simplified schematic. The apparatus provides push-button selection of matric columns by one subject and rows by his opponent who may be another subject or the experimenter. These selections determine numerical payoff values of varying desirability for the players. This conflict situation allows the psychologist to study various aspects of human behavior, such as strategy formation.

113. Schwartz, N. F., *A Pulse Function, Single Axis, Compensatory Tracking Apparatus*, ASD Technical Report 61-734, December 1961. AD 276 201.

An apparatus which provides a one-dimensional compensatory tracking task for psychological research is described. A photograph, schematics, and description of the circuitry are included. The apparatus was developed to fulfill the requirements of a task designed primarily to compare tracking performance under normal gravity to performance under zero or other abnormal gravity. The task is to attempt to keep the spot on a cathode-ray tube centered using an aircraft- or similar-type control stick. Programmed pulses having either of two ampitudes and durations and separated by either of two intervals cause the spot to suddenly move vertically either of two distances up or down from center when being tracked. These pulse parameters are programmed to seem random. The forcing function pulses driving the spot and the subject's response can both be recorded to yield specific data and, as presently used, afford a comparison of normal tracking performance with performance under zero gravity.

114. Sidowski, J. B., Kopstein, F. F., and Shillestad, Isabel J., "Prompting and Confirmation Variables in Verbal Learning," *Psychological Reports*, 8: 401-406, 1961.

The present study was designed in order to investigate the influence of prompting and confirmation variables upon the learning of a list of 15 English-Russian paired associates. One hundred and twenty Ss were assigned to one of six experimental conditions, consisting of 20 Ss each: (a) Prompting, in which the stimulus word of a pair was presented, then the response term, then S wrote the response term; (b) Prompt S-R, which was identical with Prompting except for the simultaneous presentation of the stimulus and response terms in place of the lone response term; (c) Confirmation, which followed the classical anticipation procedure (stimulus presented, followed by S's written anticipation of response term, then presentation of response term); (d) Confirmation S-R, which was identical with the Confirmation group except for the simultaneous presentation of the pair following S's anticipation; (e) Confirmation-Prompt, which required written anticipation of the response, plus written recording of the response term when it was presented during the knowledge of results interval; and (f) Simultaneous-Observation, during which Ss merely studied the paired-associates as they were presented, with no overt response required. All groups served for 12 consecutive trials (9 training and 3 test trials) during the learning session. The total number of errors and intrusions for each test trial were subjected to analysis. The retention tests indicated (a) a consistent superiority for the Prompt S-R and Simultaneous-Observation groups, and (b) a consistently greater number of errors, over all test trials, for the three conditions using the confirmation procedure.

115. Curtiss-Wright Corporation, *Study Program for Simulator Component Interconnections*. ASD Technical Report 61-71, April 1961. AD 262 512.

Component interconnecting techniques, patching logic and component distribution were developed which can be incorporated into the designs of training simulators. The techniques developed are to attain flexibility and versatility of general purpose computers for simulators to lessen the arduous operations presently incurred whenever alterations to an existing system are required. Emphasis was placed on providing a means to accomplish this desired result without increasing the size or space required for any given cabinet. In fact, using the techniques derived herein, the cabinet size and space needed has been cut down. A hermaphrodite body type of connector was selected utilizing crimp type pins and sockets, affixed to standard lengths of wire which in turn are inserted into the prescribed holes in the connector body as dictated by the electrical circuit design.

ABSTRACTS FOR 1962

116. Barcik, J. D., *Bibliography on Memory*, MRL Memorandum Report P-1, March 1962. AD 273 640.

References are provided to 658 articles on the conditions which influence human memory. Most references are to articles in psychological journals during the 1950's. The references are organized under 12 major topics with two of these (interference and organization of materials) further divided into six sub-topics and another major topic (retention) divided into three sub-topics.

117. Benenati, A. T., Hull, R., Korobow, N., and Nienaltowski, W., *Development of an Automatic Monitoring System for Flight Simulators*, MRL Technical Documentary Report 62-47, May 1962. AD 283 008.

The design study of an automatic monitoring system for flight simulators is presented. System basic functions are: 1. Recording and playback; 2. Evaluation and scoring. The recording and playback facilities allow the recording of pertinent parameters of a simulated flight mission. The recording of any part or all of the mission can be played back into the flight simulator for re-enactment at any desired time. Objective evaluation and scoring of the trainee is accomplished by comparison of monitored parameters to the programmed criteria. Student errors in performance are printed by the device onto a cue sheet readily accessible to the instructor. Functional flexibility, the degree of automation required, size, and complexity of the simulator to be monitored are the factors that most affect the design.

118. Briggs, G. E., *Pursuit and Compensatory Modes of Information Display: A Review*, AMRL Technical Documentary Report 62-93, August 1962. AD 288 888.

This report is a review of the literature on pursuit vs compensatory modes of display for continuous control (tracking) tasks. It covers published research on this topic to October 1961. The review is concerned only with those research studies in which a comparison was made of the two display modes. The review summarizes both the empirical data and the theoretical interpretations in this research area.

119. Brody, A. L. and Weinstock, S., *Mathematical Theories in Performance, Decision Making, and Learning: A Literature Review*, MRL Technical Documentary Report 62-76, July 1962. AD 285 565.

The experimental and theoretical literature on mathematical theories in psychology between 1930 and 1959 is reviewed to provide an introduction to this area for the non-mathematically trained researcher. The review is restricted to information theory, game and decision theory, and probabilistic learning theories. Six criteria for evaluating theories are also presented and used in the review. The following conclusions are drawn: (a) information theory has provided a language and an information measure but has not been used as a theory; the information measure and the noisy channel theorem are used heuristically; (b) applications of game and decision theory fail to satisfy any of the evaluation criteria; and (c) probabilistic learning theories have been developing soundly. However, the Estes theory needs to be extended to a broader variety of situations while the Bush-Mosteller theory needs a subsidiary learning theory to solve problems of coordination of theoretical terms with experimental variables and to define its range of application.

120. Buckhout, R., *A Bibliography on Aircrew Proficiency Measurement.* MRL Technical Documentary Report 62-49, May 1962. AD 283 545.

Reports on aircrew proficiency measurement have been compiled in the interest of research on the problems of assessing the performance of combat aircrew members. Particular emphasis has been placed on material related to the potential use of ground-based flight simulators as sophisticated, objective, aircrew proficiency measurement tools. The reports are listed under six sections: First Order Measurement, Combination Measures, Validation, Measurement Equipment, General Analyses and Reviews, and Background Reports. All of the reports have been coded in accordance with their relevance to kinds of aircrew tasks and to aircrew positions.

121. Buckhout, R., *A Working Bibliography on the Effects of Motion on Human Performance*, MRL Technical Documentary Report 62-77, July 1962. AD 287 530.

A bibliography compiled from a number of disciplines which bear on the problem of motion and its effects on human performance is presented. Psychophysiological reports in the area of Spatial Orientation, Perception, and Receptor Mechanisms provide background on the Human Organisms in Relation to Motion Stimuli. The Effects of Aerospace Vehicle Motion are represented by a compilation of studies of performance under acceleration, vibration and buffeting, tumbling, and weightlessness. Reports on training and motion simulation, equipment and methodology, and general analyses of the whole problem area are presented.

122. Dean, C. W. and Lisovich, J. V., *Data Flow: The General Problem and a Cognitive Model*, MRL Technical Documentary Report 62-42, May 1962. AD 283 252.

The purpose of this study was to determine the state-of-the-art in data flow and to formulate a data flow model. An investigation of the state-of-the-art was conducted, emphasizing human factors literature, which revealed that a practical data flow model does not exist. The data flow model designed for this project is intended to facilitate the understanding of system function, provide systematic techniques with which to generalize between systems, and improve communications between various disciplines involved in systems work. The model is also intended to serve as the basis for various types of system training. The mechanics of the model include a verbal representation method, and a calculus. The verbal and graphic aspects of the model facilitate the communication functional similarity or dissimilarity between both systems and parts of systems. The model calculus, based on formal logic, facilitates the analysis and perception of the functional strategies of the system.

123. Demaree, R. G., Marks, M. R., Smith, W. L. and Snyder, M. T., *Development of Qualitative and Quantitative Personnel Requirements Information*, MRL Technical Documentary Report 62-4, December 1962. AD 296 997.

This report describes the nature of, purpose and method for developing Qualitative and Quantitative Personnel Requirements Information (QQPRI). The report is intended to aid Air Force and contractor personnel in the development and use of QQPRI. The first section of the report covers the nature and scope of QQPRI and relationship of QQPRI to system development. The second section describes the general constraints within which QQPRI is developed. Such constraints include technical weapon system constraints as well as policies on Air Force Personnel, Training and Manning. The third and largest section covers QQPRI development techniques such as task analyses, estimation of performance time, establishing Air Force positions and determining the relation of these to existing Air Force specialties. The fourth section covers the QQPRI report, its preparation and uses.

124. Eckstrand, G. A., *Individuality in the Learning Process: Some Issues and Implications*, Psychological Record, 12: 405-416, 1962.

The article presents a brief and preliminary consideration of individual differences in learning. Major topics discussed are (1) implications of individuality for learning research, (2) current treatment of individual differences in learning, (3) implications of individuality for learning applications, (4) applications of individuality in education and training, (5) automated teaching and individual differences, and (6) research needs.

125. Folley, J. D., Jr., and Shettel, H. H., *Tryout of a Preliminary Procedure for Systematically Designing Performance Aids*, MRL Technical Documentary Report 62-20, April 1962. AD 283 605.

Performance aids are devices or documents that facilitate task performance by humans in a system. A procedure for designing such aids was given a limited-scope tryout on a portion of the Atlas E system. No evidence was found to contradict the performance aid recommendations generated by the procedure. The major change made in the procedure as a result of the tryout is to require providing performance aids for every task in a system except for tasks in which use of an aid would result in too slow performance. Training programs in the auto-instructional format are recommended as a routine addition to the performance aids complement. Five specific aids are recommended for the Atlas E system. Three important research problems are suggested for future research on performance aids development.

126. Jacobs, P. I., *Some Implications of Testing Procedures for Auto-Instructional Programming*, MRL Technical Documentary Report 62-67, June 1962. AD 283 359.

Although there are fundamental differences in the objectives of the two activities, the programming of instructional material bears many similarities to the construction of tests. A systematic comparison of problems and procedures reveals important implications for programming from the older field of testing. Theory and experience in test construction can be especially useful in the selection of valid criteria for assessing the effectiveness of a program, the ordering of instructional subject matter, the writing of instructional frames, and the formal evaluation of the program. Adaptive programming implies measurement of both aptitude and achievement in order to assign trainees to appropriate individual sequences of instruction. Possible applications resulting from examination of these and other issues are explored, and necessary further research is suggested.

127. Kopstein, F. F. and Cave, R. T., *Preliminary Cost Comparisons of Technical Training by Conventional and Programmed Learning Methods*, MRL Technical Documentary Report 62-79, July 1962. AD 298 766.

This report considers the comparative costs of training airmen for electronics specialties with automated and conventional instruction. Three different methods of estimating the costs of the prototype automated course for Communications Electronics Principles, Keesler Air Force Base, Mississippi are compared with the estimated costs of the current conventional course. Costs of automated instruction compare favorably with those of the conventional course regardless of the method of estimation. Further, these programming costs continue to diminish as the number of students trained increases while conventional costs remain constant. Generalizations related to the economic factors of auto-instruction are discussed in terms of general application to Air Force training courses.

128. Kopstein, F. F., Zachert, V. and Cave, R. T., *Preliminary Evaluation of a Prototype Automated Technical Training Course*, AMRL Technical Documentary Report 62-78, July 1962. AD 402 732.

The study described in this report, conducted at Keesler Air Force Base, Mississippi, constituted a preliminary evaluation of intrinsic programming for automated training. Automated instructional materials used during the first 6 weeks of the Communications Electronics Principles course were presented to beginning electronics students via 35-mm film on the Auto-Tutor Mark I, a rearview projection machine. Using the Keesler Mathematics Test, three groups--Experimental, Control, and Blind Control--were selected and matched from the middle ability range of each of two entering classes. The Experimental group received via the machines all instruction normally received through lecture and discussion. However, they followed the usual method for their practical problems. The students using machines learned adequately from this experimental program. The interpretations of these results and implications for Air Force training are discussed.

129. Krasny, L. M., *The Functional Design of a Special-Purpose Digital Computer for Real-Time Flight Simulation*, MRL Technical Doucmentary Report 62-39, April 1962. AD 283 099.

To determine the ability of a moderate-sized digital computer, such as the M.I.T. TX-0, to solve a complex real-time flight simulation problem, the complete equations for the unrestricted simulation of the F-100A aircraft have been programmed using the TX-0 order code. From an analysis of this program, specific recommendations are made for logical modifications of the TX-0 to facilitate real-time simulation. With nine additional orders, including a 25 μ sec addressable multiply, a 40 μ sec divide, and a special level-sense order to facilitate nonlinear function generation, the TX-0 would solve the full F-100A equations at 23 solutions per second. The areas of function generation, order code specification, usage of sub-routines, integration, word length requirement, input and output procedures, decision-making, and high-speed multiplication are investigated in detail with quantitative comparisons between different methods wherever possible. Although the emphasis of this study has been on the specific requirements of the F-100A problem, the design methodology and the various design trade-offs described should be applicable to the functional analysis of other simulation problems of greater or lesser complexity.

130. Krumm, R. L. and Farina, A. J., *Effectiveness of Integrated Flight Simulator Training in Promoting B-52 Crew Coordination*, MRL Technical Documentary Report 62-1, February 1962. AD 273 891.

This report represents the findings of a study designed to assess the value of a B-52 flight simulator electronically linked to a T-2a navigator trainer in promoting crew coordination. Seventy-five SAC aircrews undergoing B-52 transition training at Castle Air Force Base were used as subjects. Integrated and non-integrated simulator training of these crews was contrasted. The results, as indicated by certain of the measures used, enable a favorable recommendation to be made regarding the effectiveness of the B-52 integrated crew trainer. In the report, special attention is devoted to a discussion of two aspects of communication, pattern and volume, and the relation of these aspects to crew coordination.

131. Licklider, J. C. R., "Preliminary Experiments in Computer-Aided Teaching", in *Programmed Learning and Computer-Based Instruction*, J. E. Coulson (Ed.), John Wiley and Sons, Inc., pp. 217-239, 1962.

This chapter describes experience in the development of computer programs for the PDP-1 *Programmed Data Processor*. The PDP-1 is a small, versatile and rather fast machine and has a "sequence-break" system for time sharing. It is excellent for use in teaching machine research because its time is inexpensive enough to permit unpressured exploration and experimentation and because the sequence-break system facilitates simultaneous operation by several subjects working independently.

132. Livingston, W. A., Jr., *Outer-Space Environment Models for Use with Space Vehicle Simulators*, MRL Technical Documentary Report 62-40, May 1962. AD 283 284.

A summary of the important aspects of the environment in cislunar space is important to the simulation of space vehicles is presented. Models of this environment are developed, and estimates of the required parameters are made on the basis of currently available data. These models have been constructed with an emphasis toward maximum simplicity of representation, in order that the computations be compatible with real time simulation of space vehicles.

133. Lund, G., Hallman, R., La Monaca, R., Port, J., Questa, C., Pozran, G., Johnson, K., and Modrick, J. A., *Design of a Paired Associates Trainer for Training Research*, AMRL Technical Documentary Report 62-104, November 1962. AD 292 705.

Paired associates learning is the association of a pair of terms in such a way that when one term is presented, the other term is elicited or selected. The stimulus terms are presented one at a time to a student who responds by recalling the response terms or by selecting them from a list. A study program was initiated to develop a device to present training materials, which are reducible to a paired associates format, to a student until a specified level of mastery is reached. The Paired Associated Trainer (PAT) was designed as a research vehicle for a study program concerned with general purpose military, paired associates training devices. Complete information, including logic, circuit, and mechanical design, is given herein for a basic Trainer. Features of a proposed expanded Trainer and alternate Trainer designs are presented together with cost estimates on both the basic and the advanced Trainer.

134. McNulty, C. F., *Simulation for Spacecrew Training; State-of-the Art Review*, MRL Technical Documentary Report 62-32, April 1962. AD 283 343.

The capabilities of the existing simulation technology are discussed and various government and industrial programs for the development of new techniques required for spacecrew training are described. These techniques are divided into categories and discussed in generalities and specifics. The category most basic to the simulation of a system is the development of a suitable set of mathematical models for expressing its characteristics to the degree required. Existing equation techniques are based upon simplifications that are not valid for future type vehicles. Classical equations, although not complete, are too complex to be practical for complete simulation. Programs are discussed for the development of new coordinate schemes and generalized aerodynamic and motion equations. The application of special and general purpose analog and digital computers to simulation problems are discussed, and the development of a real-time digital computer and hybrid analog-digital computers, which appear most promising for future simulation, is reviewed. The requirements for visual capabilities in future training simulators are presented. These vehicles are expected to include a means for the operator to view the scene on the outside and must include complete simulation for generating this scene. Several programs are discussed which are intended to provide segments of the visual simulation capability.

135. Naylor, J. C., Briggs, G. E., and Reed, W. G., *The Effects of Task Organization, Training Time, and Retention Interval on the Retention of Skill*, AMRL Technical Documentary Report 62-107, September 1962. AD 289 890.

Three variables (amount of training, task organization, and length of the retention interval), each at two levels, were studied to evaluate their influence upon the long-term retention of skill. Subjects were assigned to each of the eight experimental conditions, and were given practice on the criterion task for 2 or 3 weeks. The criterion task was composed of two subtasks, a procedural task involving the learning of discrete responses to discrete stimuli and a tracking task which involves continuous control of a three-dimensional compensatory display. All subjects returned for a retention test either 1 or 4 weeks subsequent to the end of training. Amount of training had a significant influence upon the degree of measured retention loss, as did task organization under conditions of lesser training. This was found for both tracking performance and for the number of omissive errors committed in performing the procedural task. Amount of absolute retention was generally related to (a) amount of training, (b) task organization, and (c) the length of the retention interval.

136. Pask, G. and Lewis, B. N., "An Adaptive Automaton Teaching for Small Groups", *Perceptual and Motor Skills*, 14: 183-188, 1962.

An analysis is presented that indicates that automated teaching of most skills to small groups requires a special kind of adaptive automaton which can organize the group members by manipulating their channels of communication. An example of such an automaton is described and its potentialities pointed out.

137. Perry, E. L., *Submicrosecond Simulation Computer Program: I. Requirements and Techniques Study*, MRL Technical Documentary Report 62-27 (I), May 1962. AD 278 848.

Circuit techniques and memory devices for use in implementing a submicrosecond simulation computer are either currently available or are expected to become available within a short time. Saturated transistor ciruits are preferred for general usage in the system over other faster and more complex techniques because of the reduction in complexity, lower power dissipation, and more latitude in permissible tolerance variation. A basic three-memory system has been defined which provides up to 32,000 words of instruction storage, 16,000 words of data storage and 1,000 words of fast "scratch pad" storage. The bulk storage devices are expected to be composed of ferrite elements which may be sensed nondestructively at a two-megacycle rate. The "scratch pad" device will utilize magnetic films which may be cycled at a four-megacycle rate.

138. Perry, E. L., *Submicrosecond Simulation Computer Study Program: Preliminary Design Synthesis*, MRL Technical Documentary Report 62-27 (II), October 1962. AD 290 628.

The results of a research program to determine the preliminary design and system configuration of a high-speed simulation computer are described. Bench tests and analytical study of circuits utilizing the Fairchild 2N709 transistor have shown that the propagation delay through the basic diode-transistor NAND logic circuit will be approximately 4 nanoseconds. The memory study and tests have supported the use of ferrite cores for the storage bulk program data. These cores may be sensed non-destructively at a two-megacycle rate by means of a flux-direction sensing technique. A fast scratch-pad memory is provided to compensate for the characteristically slow writing rate (250 KC) associated with the non-destructive read-out memory. The computer described is designed to achieve a 0.75 μs floating point addition operation time using these circuits and memories. The system organization will permit the computer to be applied to a variety of real-time simulation problems without any change in its basic structure. A variety of input/output equipment can be attached to the basic computer to adapt it to any particular simulation need. Memory quantity may be specified in module sizes of 4 thousand words. A rapid access optional drum memory may be used to reduce the amount of random access storage for certain types of simulation applications. An independent search feature and input/output operations, which do not interrupt the execution of the main program, serve to increase the effective computing capability of the system.

139. Smode, A. F., Gruber, A., and Ely, J. H., *The Measurement of Advanced Flight Vehicle Crew Proficiency in Synthetic Ground Environments*, MRL Technical Documentary Report 62-2, February 1962. AD 273 449.

This report is devoted to the presentation and discussion of major considerations in the design of systems for measuring the proficiency of advanced flight vehicle crews in synthetic ground environments. Emphasis is given throughout to the logic of proficiency measurement and the general problems involved rather than to the analysis of specific details. Successive portions of the report deal with general measurement concepts, procedures and steps in designing measurement systems, an example application of the material presented, and the anticipated characteristics of advanced flight vehicle simulation equipment related to proficiency measurement. In addition, a historial overview of aircrew proficiency measurement emphasizing early work and a list of study references on rating methods are appended. As it provides a considerable background of information on proficiency measurement, this report will be of interest to individuals directly concerned with simulator training programs, proficiency evaluation and standardization, training standards, and training equipment procurement for advanced flight systems.

140. Thackray, R. I., *Rate of Learning and Autonomic Divergence*, AMRL Memorandum Report P-11, August 1962. AD 284 051.

In order to investigate further the possible relationships between rote learning and autonomic activity, 26 Ss were given a list of nine, two-place numbers to learn by the method of serial anticipation. Measurements were made of heart rate, heart rate variability, pulse velocity, conductance level, and frequency of GSR activity during the last five minutes of resting and the first five minutes of learning. The results of this experiment show that: 1. Rate of learning was not related in any systematic way to mean T scores of the various physiological measures obtained under either resting or learning conditions. 2. There was a suggestion of an inverted U relationship between each S's mean T score across all physiological variables and rate of learning. Poor learners tended to have mean T scores which were either above or below the values obtained for superior learners. Heart-rate variability was found to be the single variable contributing most to the relationship. 3. A significant correlation was obtained between each S's rate of learning and the SD of his five physiological T scores obtained during learning. This finding indicates a tendency for greater autonomic dispersion to be related to decreased learning efficiency.

141. **Ugelow**, A., *Motivation and the Automation of Training: A Literature Review*, MRL Technical Documentary Report 62-15, March 1962. AD 277 287.

Controlling the motivation of learners in their continuing use of the new auto-instructional devices could become a serious problem, since neither the devices themselves nor the performance knowledge they provide seems sufficient to maintain extended participation in the instruction. A selective review of the literature on knowledge of results, praise and reproof, competition, task interruption, and readability suggests techniques for better controlling such participation. Potentially useful applications are discussed, and limited try-out of variations, both within the program and instructional environment, is encouraged.

142. Wiener, E. L., *Knowledge of Results in a Monitoring Task*, AMRL Technical Documentary Report 62-82, August 1962. AD 290 059.

An experiment was performed to determine the transfer effect of knowledge of results and signal rate of performance in a Mackworth-type vigilance task. Subjects were run the first day under feedback conditions of zero, partial, and full knowledge of results, and 16, 32, and 48 signals during 48 minute run. On the second day all subjects were run under the conditions of zero knowledge of results and 32 signals. The results showed that the two experimental variables differentiated subjects on both the initial exposure and the transfer condition. In terms of percentage of signals detected, groups initially trained with knowledge of results and high signal rates showed superior performance on both days. The usual decrement in performance over time was noted on both days. With respect to commissive errors, large individual differences contaminated the results. The data suggest that partial knowledge of results may encourage the operator to make more commissive errors than either zero or full feedback. The findings appear to recommend training with full knowledge of results and high signal rates when an operator must be placed in a situation with no knowledge of results and low signal rates.

ABSTRACTS FOR 1963

143. Askren, W. B., Jr., *Bibliography on Maintenance Personnel Performance Measurement*, AMRL Memorandum Report P-45, June 1963. AD 439 610.

This report lists 116 articles related to measuring the performance of maintenance personnel. The articles are grouped into three categories of electronic maintenance, general maintenance, and general information on performance measurement. The bibliography was compiled primarily by a search of 17 different descriptors of the Defense Documentation Center, and 13 areas of the *Psychological Abstracts* from 1942 through 1962. Various other sources also were screened. The eleven most "productive" researchers in the area of performance measurement were determined by analysis of the bibliography. The distribution of references by year of publications was tabulated and graphed.

144. Bernstein, B. R., Kristofferson, A. B., and Modrick, J. A., *Interaction Between Subject Variables and Conditions of Learning: A Preliminary Study*, AMRL Memorandum Report P-61, October 1963. AD 431 853.

A preliminary investigation was made of the interactions which might exist between certain individual differences and various learning conditions. Each subject learned a list of twenty paired adjectives under one of the following modes on the Subject Matter Trainer: (a) the Quiz Mode, in which the subject could elicit the correct response to a given stimulus without first attempting to guess the correct answer; (b) the Modified Quiz Mode, in which the subject was required to make one guess before being shown the correct response; (c) the Practice Mode, in which the subject was required to continue guessing until he discovered the correct response; and (d) the Single-Try Mode, in which the subject made a single guess on each item and was informed only that this guess was correct or incorrect. Fifteen subjects were assigned to each mode. In addition, scores were obtained from each subject on each of the following tests: (a) a test of verbal reasoning; (b) a test of symbolic reasoning; (c) the F Scale; (d) the Stroop Test; (e) liability of skin conductance; (f) a reversed reading test; (g) the Luchins Water Bottle Test; and (h) the Witkin Embedded Figures Test. A separate analysis of trials to criterion was performed for each of the eight indices of individual differences. Only one of these (that for the Stroop Test) indicated a significant interaction between modes of presentation and scores (high vs low) on one of the eight tests.

145. Brown, D. R., Naylor, J. C. and Briggs, G. E., *The Retention of Discrete and Continuous Tasks as a Function of Interim Practice with Modified Task Requirements*, AMRL Technical Documentary Report 63-35, May 1963. AD 408 980.

Laboratory research is reported on retention of continuous (tracking) and of discrete (procedural) tasks as a function of rehearsal conditions (simplified versus "operational" rehearsal tasks). All rehearsal conditions led to superior retention of the tracking task compared to a no-rehearsal condition and certain of the procedural task scores indicated the same result. However, little evidence was found to indicate reliable differences among the several rehearsal conditions. It was concluded that sufficient original training will eliminate any potential differences among rehearsal conditions.

146. Buckhout, R., Goldsmith, C. T., Sherman, H., and Vitale, P. A. *The Effect of Variations in Motion Fidelity During Training on Simulated Low-Altitude Flight,* ARML Technical Documentary Report 63-108, December 1963. AD 435 543.

Two experiments testing the effects of variations in the fidelity of simulated motion during training on performance in a simulated low-altitude, high-speed mission were performed. The simulated mission required subjects to perform a one-dimensional (vertical) compensatory tracking task, while experiencing moderately heavy clear air turbulence. The research led to the following conclusions: 1. Providing simulated motion during the learning of tracking skills contributes to more effective performance in criterion situations in which motion cues play an important role. 2. Performance on a procedural task (reaction time measures) during criterion testing did not differ significantly as a function of the type training received.

147. Buckhout, R., Naylor, J. C., and Briggs, G. E., *Effects of Modified Task Feedback During Training on Performance of a Simulated Attitude Control Task after Thirty Days,* AMRL Technical Documentary Report 63-125, December 1963. AD 431 215.

This study was to determine the effects of modifications in task feedback during training on performance of a simulated attitude control task after a 30 day interval. The criterion task consisted of compensatory rate tracking in three dimensions by means of "noisy" meter displays and a conventional stick with a twist dimension added. In addition, the intensity of auditory noise present varied proportionately to tracking error in four steps. Equal numbers of subjects trained for 1 or 3 weeks with either noisy or non-noisy displays and under one or two degrees of auditory feedback specificity (magnitude of steps used to relate visual noise to error score). Subjects trained with visual noise showed better performance after 30 days despite the fact that subjects trained with a noise-free display performed significantly better tracking performance on 30-day retention test than subjects who received only 1 week of training. The use of more gross steps in auditory noise in training did not significantly affect retention test performance.

148. Buddenhagen, T. F., Johnson, A. B., Stephan, S. C. and Wolpin, M. P., *Development of Visual Simulation Techniques for Astronautical Flight Training*, Vol. I. *High Resolution Television; Electronic Planetarium*, AMRL Technical Documentary Report 63-54, Vol. I, June 1963. AD 412 641.

Extra wideband closed-circuit television was studied to evaluate high resolution closed-circuit television and high gain projection screens, and to develop a technique for electronic generation of the celestial star field. Wideband television state-of-the-art was studied and performance growth for ten years is predicted. The evaluation of a 20-mc television system led to greater understanding of the capabilities and limitations of wideband television systems. The investigation of high gain projection screens examined the areas of simulation in which the various types of screen material are most useful and those in which further development is needed to realize the full potentials of material designs. The development of the electronic generation of the celestial star field demonstrates the feasibility of the electronic storage of digital data for the description of visual scenes.

149. Castruccio, P. A., Loats, H. L., Jr, and Modrick, J. A., *Training and Training Equipment Requirements for Ground Operators and Maintenance Personnel of Advanced Space Systems*, AMRL Technical Documentary Report 63-67, July 1963. AD 417 183.

Training requirements for ground operator and maintenance personnel of manned space systems of the 1960-1975 era are examined. Hypothetical models for an earth orbital and lunar vehicle are formulated from an analysis of space missions proposed by NASA and USAF as of July 1962. Probable components and characteristics of major facilities and vehicular subsystems are described; this material is based on an analysis of mission requirements and a projection of engineering technology over the time span of the study. Future propulsion and life support equipment are identified as requiring new skills due to the adoption of nuclear propulsion and closed cycle life support subsystems. Functional changes will occur in guidance/navigation, control and auxiliary power equipment but no new skills will be required. Tasks required of future guidance/navigation, nuclear propulsion and life support technicians are projected. Subsystem composite and component test procedures are described and test equipment, skills and knowledges are identified. A more detailed malfunction and trouble-shooting analysis is presented for closed cycle life support equipment. A general outline of training content for these specialties is given and a list of proposed training equipment and aids is coordinated to these outlines.

150. Chiles, W. D. and Custer, Carolyn, L., *Summaries of Research on the Human Performance Effects of Vibration*, AMRL-TR-67-172, November 1963. AD 666 425.

This report is a compilation of summaries of published reports dealing with the human performance effects of low frequency, high amplitude vibration. The research described in each report is covered as fully as possible as regards the information needed to evaluate the investigations with respect to their applicability to Air Force operational human performance problems and research efforts. However, the implications of the reports for Air Force problems are not discussed as such.

151. Foley, J. P., Jr., *Performance Testing: Testing for What is Real*, AMRL Memorandum Report P-42, June 1963. AD 412 776.

It is generally conceded that performance examinations are superior to written examinations for the measurement of job behaviors required of Air Force specialists and technicians. However, performance examination, both in school and on-the-job, are time consuming in their development and in their administration. Written examinations have, therefore, been substituted in many cases for performance examinations. This memorandum presents the difficulties involved in developing and administering performance examinations, the dangers of depending on written examinations as substitutes for performance examinations, and the fact that there is a lack of research information on the valid substitution of written for performance examinations. It proposes developmental research with a view of simplifying performance examination procedures and establishing valid guidelines as to the scope of written examinations in measuring job behaviors. It, also, makes some recommendations concerning immediate action that can be taken to improve the validity of current technical training examination procedures.

152. Gerhardt, L. and Johnson, A. B., *Development of Visual Simulation Techniques for Astronautical Flight Training, Volume II: Image Assembly Techniques for Visual Simulation of Orbiting Flight*. AMRL Technical Documentary Report 63-54, Vol. II, November 1963. AD 427 318.

A program was conducted to study techniques for the development of keying signals, to develop a switching amplifier compatible with high resolution television equipment, and to experimentally evaluate the performance of a 1 1/2 inch vidicon camera and a modulated light beam television projector. The various possible methods of developing a keying signal for matting control of multiple image generation were studied in an effort to determine the best techinque for application to the simulation problem. A switching amplifier was developed to fill a gap existing in available high resolution equipment. A new 1 1/2 inch vidicon camera was documented for future applications in the simulation field. A modulated light beam projector was also documented for future reference.

153. Greenspoon, J., *The Effects on Transfer of Time Delay and Task Similarity: A Literature Review,* AMRL Technical Documentary Report 63-22, March 1963. AD 404 229.

A review of selected literature pertinent to the effects of similarity and delay on transfer is reported. Emphasis is given to the more recent research and that which seems to make greater contribution to knowledge of these effects, especially studies in which similarity and time delay were manipulated jointly. Although considerable research has been accomplished, the effects of similarity and time delay (either singly or jointly) are not known with sufficient precision to enable satisfactory use outside of the narrowly constrained laboratory contexts, if even there. Effective prediction on the basis of similarity will depend on the development of a rigorous and reliable technique for its measurement. The effects of delay can only be adequately determined after this is accomplished.

154. Greenspoon, J. and Anderson, J. E., Jr., *Effects of Stimulus Similarity and Delay on Transfer of Training,* AMRL Technical Documentary Report 63-26, April 1963. AD 415 728.

This research was concerned with the effects of stimulus similarity and delay on transfer to a visual-motor task. Subjects were trained on the same stimulus value and then retrained on the same or different stimulus values after varying intervals of time. The results indicated that both variables significantly affected the amount of positive transfer, although the results were not unequivocal. The greatest amount of transfer occurred on stimulus values that were closest to the stimulus value of original training. Moreover, the longer time intervals between original learning and test of transfer tended to produce the greater amount of transfer. The transfer effect tended to be short lived in that subjects who had no prior experience with the task were performing as well as the subjects with prior experience after a relatively small number of trials.

155. Haines, D. B. and Gael, S., *Estimating Manning Requirements for Advanced Systems: A Survey of the Defense Industry,* AMRL Technical Documentary Report 63-110, November 1963. AD 432 483.

The findings of a special survey of the manning estimation techniques used by the defense industry are summarized. The defense industry was asked for their methods and problems of estimating manned requirements of advanced weapons systems. The survey was part of a long range program of research aimed at the identification and quantification of manning requirements for advanced weapon systems. A five item, open-ended questionnaire was sent to human-factors specialists in key defense industries. Respondents were asked to list their experience in predicting manning requirements for systems, to cite the guides and publications most useful in making these predictions, and to describe the method used in arriving at manning estimates. Five different approaches to estimating manning were reported; the most popular being the use of task analysis or some combination of task analysis with variations of the other approaches. Other methods were: expert estimation, historical comparison, sovereign factors and mathematical models. The most frequently cited guides were USAF publications, but a wide variety of other texts, handbooks, and technical publications were also reported. Respondent experience ranged over the major weapon systems, subsystems and control networks. The report concludes with suggestions for the characteristics of a method acceptable to industry.

156. Hall, E. R., *The Checkout and Maintenance (CAM) Trainer*, AMRL Memorandum Report P-35, May 1963. AD 409 585.

The Checkout and Maintenance (CAM) Trainer is a major device that has been specially constructed for research on electronic maintenance. The device has been designed to support research on problems such as the following: determining the major sources of difficulty in electronic maintenance; specifying the most efficient techniques and devices for training and aiding electronic maintenance personnel; and developing effective techniques for evaluating the proficiency of personnel performing electronic maintenance.

157. Hall, E. R., Modrick, J. A., and Richard, P. R., *The Checkout and Maintenance (CAM) Trainer: I. Instructions and Programs for Use*, AMRL Memorandum Report P-39, June 1963. AD 413 524.

This report is intended primarily as an aid to those using, or planning to use, the Checkout and Maintenance (CAM) trainer. The report provides a brief description of the CAM trainer, detailed instructions for its operation, and the instructional programs prepared for use with the trainer. These programs teach checkout procedures and other information relevant to the operation of the radar system used with the trainer. The CAM trainer was developed for use in research to improve electronic maintenance. It includes an AN/ASB-4 radar bombing navigational system special electronic equipment to make the system function on the ground, a specially constructed device for presenting instructions to a student, and equipment to measure the student's performance. Under controlled conditions, the CAM trainer presents tasks similar to those encountered in the maintenance of modern complex electronic systems. These tasks can be used for research on problems such as determining the major sources of difficulty in electronic maintenance, determining the best techniques and devices for training and aiding electronic maintenance personnel, and developing techniques for evaluating the proficiency of personnel performing electronic maintenance.

158. Hall, E. R., Modrick, J. A., Richard, P. R., and Moss, J. L., *The Checkout and Maintenance (CAM) Trainer: II. Description and Functional Characteristics*, AMRL Memorandum Report P-51, July 1963. AD 417 417.

The Checkout and Maintenance (CAM) Trainer is a major device that has been specially constructed for research on electronic maintenance. The device has been designed to support research on problems such as: determining the major sources of difficulty in electronic maintenance, specifying the most efficient techniques and devices for training and aiding electronic maintenance personnel, and developing effective techniques for evaluating the proficiency of personnel performing electronic maintenance. The major components of the CAM Trainer are an operational AN/ASB-4 radar system, a student console teaching device for representing information relevant to the operation of the ASB-4 system, an experimenter's station for recording data and controlling the operation of the student console, and special malfunction generation equipment for inserting controlled malfunctions into the ASB-4 system. This report describes the major components of the CAM trainer, their interrelationships and functional characteristics. Schematic diagrams relevant to the Trainer are also presented.

159. Johnson, K. A., *Troubleshooting Strategies and Utility for Risk*, AMRL Technical Documentary Report 63-92, October 1963. AD 424 506.

Sixty-one subjects were administered a battery of tasks which consisted of: (a) a paper and pencil troubleshooting task, (b) a selective concept formation task, (c) 10 tasks designed to provide indexes of utility for risk, and (d) 4 tasks of quantitative intellectual ability. Both the troubleshooting and concept formulation tasks were scored for: (a) premature attempts at final solutions, (b) totally redundant information seeking moves, and (c) the average expected reduction in uncertainty provided by moves other than those considered above. In spite of relatively high reliabilities, parallel indexes of problem-solving efficiency were almost completely independent of one another. The various indexes of utility for risk appeared to be almost completely independent of one another. No simple index, whether of utility for risk or intellectual ability, accounted for more than 20% of the variability of any of the indexes of problem solving efficiency.

160. Kinkade, R. G., *A Differential Influence of Augmented Feedback on Learning and on Performance*, AMRL Technical Documentary Report 63-12. February 1963. AD 402 973.

A test was conducted of the hypothesis that the training value of augmented feedback in a tracking situation will depend upon the discernibility of input and fundamental feedback signals.

Subjects performed a one-dimensional compensatory tracking task using a knob for positional control over the cursor. For two of four groups of subjects the reference element was noisy, oscillating at random about a null position, while for the other two it was not. Augmented feedback, in the form of auditory clicks at the rate of 2 per second when on target, was given one of each pair of groups during training. On subsequent test the performance of the group trained with augmented feedback and performing with the noisy display deteriorated to the level of its control group trained without feedback. But, the performance of the group trained with augmented feedback and performing on the noise-free display continued unchanged and superior to that of its control group trained without feedback. The results are regarded as confirming the hypothesis and as helping to explain previous contradictory findings on the value of augmented feedback.

161. Kristofferson, A. B., Modrick, J. A., and Morgan, R. L., *A Comparison of Modes of Presentation of Paired-Associates on the Subject-Matter Trainer*, AMRL Memorandum Report P-46, June 1963. AD 421 795.

An experiment was conducted to evaluate the effectiveness of each of four modes of the Subject-Matter trainer. The modes were (a) the Quiz Mode, in which the subject was shown sequentially the correct response following the presentation of each stimulus, (b) the Modified-Quiz Mode, in which the subject was allowed one free choice before being shown the correct response, (c) the Practice Mode, in which the subject responded freely until he found the correct response, and (d) the Single-Try Mode, in which the subject was allowed only one response to each stimulus. Four groups of 24 subjects each were used. Each group learned under a different mode of the Subject-Matter trainer. Each subject learned 20 paired adjectives to a criterion of two successive, completely correct trails. Retention was measured after one day and after seven days. The Quiz Mode was superior to the other modes, all of which involved active participation and some degree of feedback. Retention after one day was almost perfect for all groups. The amount retained after seven days did not differ significantly among the groups. The results seem to contradict the general principle that active responding with feedback tends to produce more efficient learning. An explanation of the apparent contradiction undoubtedly lies in (a) the temporal relationships between stimuli and their associated responses and (b) the mediating processed between stimuli and responses of the type used in this study. Information on these relationships will contribute significantly to both training and educational technology and to more comprehensive theories of human learning.

162. Kurtzberg, J. M., *Dynamic Task Scheduling in Flight Simulators*, AMRL Technical Documentary Report 63-17, February 1963. AD 402 383.

This report deals with the possible mechanization of dynamic task scheduling in flight simulators, i.e., developing a Task-Sequencer. Attention is focused on the possible application of some of the heuristic programming techniques and an evaluation of their worth for that specific purpose is made. Two main applications for a Task-Sequencer are defined. The first involves the traditional training of students (flight crews) for flight vehicle operation, termed the operation-teaching mode. The second is for the development of tactical skill, i.e., crew decision-making capabilities, termed the tactic-teaching mode. A procedural training model is developed in detail for the operation-teaching mode. This includes development of specific task flow diagrams and associated scoring charts. Finally, recommendations are made for further work.

163. Miller, E. E., *A Classification of Learning Tasks in Conventional Language*, AMRL Technical Documentary Report 63-74, July 1963. AD 419 122.

Classifying learning tasks may aid in analyzing training requirements and applying learning principles. To this end the term "learning task" is defined for purposes of the classification, and a descriptive system is introduced for analyzing training requirements and for relating various practice conditions. A logically exhaustive classification is presented. Learning tasks are categorized by applying the definitional criteria sequentially. Major categories are "perceptual-motor," "discovery," "understanding," "perceptual judgement," and "memorizing," corresponding roughly with common usage of the terms. The criteria for class membership are of three kinds: (a) discrepancies between criterion performance and initial skills of trainees, (b) restrictions on practice conditions considered legitimate in meeting the particular performance test, and (c) the kind of overt behavior constituting criterion performance and the allowable alternatives in such performance. The restricted applicability of generalizations about learning to certain categories is discussed.

164. Naylor, J. C. and Briggs, G. E., "Effect of Rehearsal of Temporal and Spatial Aspects on the Long-Term Retention of a Procedural Skill," *Journal of Applied Psychology*, 47: 120-126, 1963.

The study examined several rehearsal techniques as means of facilitating the retention of a discrete procedural task. Four rehearsal conditions were defined as: whole task rehearsal, temporal rehearsal, spatial rehearsal, and no rehearsal. All groups were trained for 5 days, given 10 days of no practice, 5 days of rehearsal, 11 more days of no practice, and a retention test. The number of commissive errors showed significant retention differences, with the whole rehearsal group performing best. Omissive errors and reaction time did not show group differences. It was also found the *Ss* emphasized those metrics of performance which gave the most immediate feedback.

165. Naylor, J. C., Briggs, G. E. and Buckhout, R. J., *Long-Term Skill Transfer and Feedback Conditions During Training and Rehearsal*, AMRL Technical Documentary Report 63-136, December 1963. AD 431 222.

Eight groups of subjects performed a continuous tracking and procedural task under various conditions of auditory performance feedback during training (8 days) and rehearsal (3 days). Four degrees of auditory cueing were used during training by varying (in size) the stepwise relationship between intensity of noise and amount of tracking error in three amounts plus a control condition of random noise. Two rehearsal conditions were used to complete the factorial arrangement--feedback similar to training versus random feedback. Rehearsal occurred 14 days after the completion of training and a transfer test to the medium-noise condition was conducted 14 days following the last rehearsal session for all groups. Transfer performance was found to be significantly related to feedback specificity during training (medium specificity was inferior to either high or low specificity), while the rehearsal variable had no statistical effect on performance with any performance metric.

166. Naylor, J. C., Briggs, G. E., Brown, D. R. and Reed W. G., *The Effect of Rehearsal on the Retention of a Time-Shared Task*, AMRL Technical Documentary Report 63-33, April 1963. AD 408 554.

Two studies were performed to investigate the influence of various methods of task rehearsal upon the retention of a time-shared task. Experiment I examined retention as a function of four rehearsal conditions (part task, whole task, simplified task, and none). Subjects in each of the groups trained for 8 days and returned 6 days later for 2 days of rehearsal, and then returned again after 7 more days for a retention test. Experiment II examined retention both as a function of 3 rehearsal methods (whole, part, and none) and amount of training (5 or 10 days). Subjects returned for 2 days of rehearsal 10 days after completion of training and then returned for rehearsal methods. In Experiment I part rehearsal was superior, while in Experiment II whole rehearsal was found to be best.

167. Reed, L. E., Foley, J. P., Jr., Graham, R. S. and Hilgeman, J. B., *A Methodological Approach to the Analysis and Automatic Handling of Task Information for Systems in the Conceptual Phase*, AMRL Technical Documentary Report 63-78, August 1963. AD 419 018.

Adequate consideration of the human skills required by future systems has long been neglected in the conceptual phase of man-machine system development. This neglect in part has been due to lack of a uniform and workable method for gathering, processing, and using early human factors information for improving the design and development of systems. The methodological approach presented in this report was predicated on this need. This report presents a technique for analyzing and processing task and task requirements data generated during the conceptual phase of system development. The technique includes: (a) category system for organizing, classifying, and coding task information; (b) a task analysis format for recording and coding task descriptions and task requirements; and (c) computer update and retrieval programs. Task requirement data appearing in documents resulting from the Air Force Study Requirement program are analyzed and used for testing the technique on an actual personnel training problem. The test program indicates that the technique can be used to assist human factors specialists to isolate and process task and task requirements associated with advanced systems for making personnel, training and training equipment recommendations.

168. Richard, P. R., Moss, J. L. and Hall, E. R., *The Checkout and Maintenance (CAM) Trainer: III. Malfunction Simulator*, AMRL Memorandum Report P-62, October 1963. AD 431 852.

This report describes the Malfunction Simulator that has been incorporated into the Checkout and Maintenance (CAM) trainer. The Malfunction Simulator supports use of the CAM Trainer for research on electronic troubleshooting. The report indicates the components of the Malfunction Simulator, its general design and operation, and general procedures for programming malfunctions into the AN/ASB-4 Radar System which is one of the major components of the CAM Trainer. Schematics, block diagrams and photographs are included. Basically, the Malfunction Simulator consists of two units; a malfunction insertion unit and a control rack. The malfunction insertion unit can be easily inserted in the circuit immediately before any of the many minor components of the AN/ASB-4 Radar System. By use of the control rack, the malfunction insertion unit can open ("break") any one of up to 30 wires leading to the component of the AN/ASB-4 system, thereby producing the desired malfunction in the system.

169. Ryken, J. M., Emerson, J. E., Onega, G. T. and Bilz, J. L., *Study of Requirements for the Simulation of Rendezvous and Docking of Space Vehicles*, AMRL Technical Documentary Report 63-100, October 1963. AD 425 499.

This report presents results of a study to establish rendezvous and docking systems which have been proposed. A complete simulation of a representative automatically controlled rendezvous and docking system was formulated and programmed on an IBM-7090 digital computer. Sufficient flexibility was incorporated into this simulation so that the proposed rendezvous and docking techniques could be studied. This program was used to determine digital computer requirements for the simulation of rendezvous and docking systems. Mission runs were made covering terminal guidance, docking, departure, retro, and deorbit to the earth's atmosphere. A simplified simulation of rendezvous and docking was programmed on analog computers and coupled with a cockpit simulator. This simulation included an electronic image generation of a target vehicle as viewed by an astronaut through a window in the interceptor vehicle. Information on accuracy of this simulation, pilot control capabilities, and control techniques was obtained.

170. Senter, R. J. and Bernstein, B. R., *Short-Term Memory as a Predictor of Troubleshooting Skills*, AMRL Memorandum Report P-53, July 1963. AD 417 418.

As an adjunct to research on transfer of troubleshooting skill, a battery of tests (both standard and new) was administered to subjects in an attempt to develop tests for the selection of personnel most suited for learning to troubleshoot. This report describes one of the new tests, a test of short-term memory, and indicates its value as a predictor of learning to troubleshoot. The Short-Term Memory Test consisted of 21 subtests, or sets of different items. Each subtest was studied by the subject for a specified short period, then it was removed and the subject's memory of the materials was tested. Various types of tests of memory were used, e.g. reconstruction, true-false, multiple choice, etc. Performance on the Short-Term Memory Test correlated significantly with some measures of learning to troubleshoot some equipment. Higher correlations were obtained when subjects received incentive pay for better performance on the Short-Term Memory Test. Under the condition of incentive pay, the correlations between short-term memory and learning to troubleshooting were generally comparable to the correlations obtained between learning to troubleshoot, and standard tests of symbolic reasoning and verbal reasoning.

171. Senter, R. J. and Nairne, F., *A Test of Troubleshooting Strategy in Paper-Pencil Form*, AMRL Memorandum Report P-54, July 1963. AD 417 419.

As an adjunct to research on transfer of troubleshooting skill, a paper and pencil Troubleshooting Simulation Test (TST) was developed. This test was administered to subjects in an attempt to obtain validating data regarding the potential value of such tests for the selection of personnel most suited to learn to troubleshoot. The TST consisted of 13 items. Each item was composed of several (3 to 32) overlapping geometric figures. The points of union of the various figures were marked with an "X". The subjects' task was to discover the "mystery" figure (known only to the experimenter) by sequentially selecting "X's." A given figure could contain many "X's", sharing each with different overlapping figures. The subject was informed whether or not the selected "X" was within the "mystery" figure. Performance on the Troubleshooting Simulation Test (TST) correlated significantly with measures of learning to troubleshoot equipment. The concept of a paper and pencil "simulation of troubleshooting" test for selecting personnel to learn troubleshooting tasks was supported.

172. Smith, E. A., Roberts, R. E. and Brady, W. E., *A Portable Presentation Package for Audio-Visual Instruction*, AMRL Technical Documentary Report 63-91, November 1963. AD 427 777.

The Portable Presentation Package is a prototype of a self-contained package of audio and visual equipment designed to facilitate technical training particularly in (a) remote areas, (b) situations in which written communications are difficult, and (c) situations requiring rapid on-the-spot preparation of instructional material. The package contains the essential components required in preparing and giving visual and audio-visual presentations to small groups. The major criteria employed in developing the package were that (a) the equipment be easily portable by one man, (b) it utilize off-the-shelf items presently available through established commercial channels, and (c) components be assembled as modules to allow replacement or substitution as units without interference with other components. The Portable Presentation Package is only slightly larger than an attache case, weighs 23 pounds, includes camera with light meter, projector with remote controls and supplementary lenses, projection screen, tape recorder and the necessary power cords and mirrors, and additional film and magnetic tapes. Descriptions and drawings are presented in the report.

173. Swets, J. A., Feurzeig, W., Harris, Judith R., and Marill, T., *The Socratic System: A Computer System to Aid in Teaching Complex Concepts*, AMRL Memorandum Report P-43, June 1963. AD 421 792.

This report presents the general rationale, approach and instrumentation required for research on the use of digital computers to aid in teaching complex concepts, problem solving, etc. Two computer-controlled instructional systems are described. These systems are considered as early prototypes of teaching systems in which the student has full control over the progression of a complex lesson. Such a system allows individually directed interaction with the subject matter. Systems of this type hold considerable promise for automated instruction of problem solving and other complex intellectual skills. Immediate research directions also are indicated.

174. Wickens, D. D., and Chambers, A. N., *An Investigation of Conditions Influencing the Development of Perceptual Sets*, AMRL Technical Documentary Report 63-98, October 1963. AD 432 498.

The experiment was designed to measure transfer effects in a perceptual-motor task when (a) the critical stimulus dimension which was irrelevant in the first task became relevant for performance on the second task and (b) where the same stimulus dimension was relevant for both tasks but responses were interchanged. The experiment was conducted in two sessions separated by 24 hours. On Day 1 subjects learned to make the appropriate one of four responses to each of a series of 16 stimuli in terms of four stimulus cues based on either the form or color properties of the stimuli. On Day 2 subjects of different groups learned critical variants of the original task. The data suggest that (a) negative transfer is greater when shifting from one dimension of relevance to another than when changing the responses required within the same stimulus dimension and (b) only weak evidence that partial reinforcement is responsible for the difficulty in shifting to learning in the new dimension. These results imply that, in designing a trainer, it would be highly inadvisable to include a stimulus dimension which would be relevant in the operational situation and not have it relevant for performance on the trainer.

175. Winner, R. N. and Zilgalvis, A., *Cathode-Ray Tube Instrument Synthesis System*, AMRL Technical Documentary Report 63-84, October 1963. AD 424 542.

A design study was conducted leading to development of a flexible laboratory design tool for synthesizing and analyzing cockpit displays. The resulting cathode-ray tube instrument synthesis system (CRT-ISS) is compatible with standard analog computer systems and has a self-contained provision for generation of 50 alpha-numeric and geometric symbols, each of which can be displayed by any or all of the 64 time-shared channels. In addition, the size, static vertical and horizontal positioning, and intensity of each symbol displayed can be independently controlled for each of the 64 channels. The preprogramming of the display is accomplished by patch cord plugging and adjustment of potentiometers. The output of the system consists of X-, Y-, and Z-axes signals which permit driving conventional cathode-ray tube oscilloscopes singly, in multiples, or in various combinations. An additional task of the design study was the development of a 21 inch solid-state display oscilloscope.

176. Battelle Memorial Institute. *Development of an Analog Multiplier, Based on Hall Effect*, AMRL Technical Documentary Report 63-50, April 1963. AD 410 897.

This report describes the development of fabrication techniques for construction of a silicon Hall effect element with characteristics suitable for application in an analog multiplier. The relative merits of various semiconductor materials are considered, and the reasons for the selection of silicon are outlined. The considerations necessary for the design of the element package structure are developed, and the tests required to characterize the Hall element in terms of electronic design parameters are also developed. Approximately 24 successful silicon elements were produced, and three pairs were mounted in suitable magnetic structures so as to obtain complete element packages. Experimental transistorized circuitry was constructed for use with these element packages in order to exhibit the ability of the silicon Hall device to multiply.

177. Behavioral Sciences Laboratory, *Considerations in the Design of Automatic Proficiency Measurement Equipment in Simulators*, AMRL Memorandum Report P-40, June 1963. AD 417 425.

The report describes the purpose of scores, their development, and current Air Force Aircrew proficiency evaluation techniques as background for a discussion of the potential use of automatic scoring equipment in conducting proficiency evaluations in flight simulators. A hypothetical automatic scoring system is considered in light of existing programs to show the advantages and disadvantages of the concept. Specific suggestions regarding the design and use of such a system are given. Automatic scoring in ground training systems may provide a means of conducting thorough proficiency evaluations, yielding scores which can be obtained more reliably, more accurately, more economically and in less time than current inflight subjective evaluation methods. In this way automatic scoring could satisfy a definite need for future proficiency evaluations of advanced aircraft and space vehicle crew members, which cannot be satisfied by present scoring systems.

178. Sylvania Electric Products, Inc., *The UDOFT Flight Simulation System.* AMRL Technical Documentary Report 63-133, December 1963. AD 431 205.

This report describes UDOFT (Universal Digital Operational Flight Trainer), the first full-scale application of a high-speed, general purpose digital computer to the real-time flight simulation problem. Through the use of the stored program digital computer, simulation of different aircraft is accomplished by changing the computer program. This flexibility is the key to the realization of the full advantages of the digital control system, as compared to the conventional analog control system, in this application. Basically a high-speed, general-purpose digital computer, the UDOFT computer represents an advancement in the design of real-time control computers. With the use of dual, 4096-word, random-access, magnetic core memories, the basic instruction time for the UDOFT computer is five microseconds. To interface with the analog environment of a flight compartment, the UDOFT computer is equipped with a special purpose, real-time input-output capability. Use of the computer in a simulation system demanded the preparation of programs for applying the computer to the solution of the mathematical model of the real-world system under consideration. Such programs were written for the F-100A and the F-9F-2. Extensive qualification testing was performed to ensure proper and complete simulation of these aircraft.

ABSTRACTS FOR 1964

179. Abma, J. S., *Programmed Instruction--Past, Present, Future,* AMRL Technical Report 64-89, September 1964. Also in *RTD Technology Briefs,* AFSC, USAF, October 1964. AD 607 809.

Programmed instruction has existed in its present forms for approximately ten years. Three major approaches are: the "Adjunct Autoinstruction" of Sidney L. Pressey, the "Intrinsic Programming" of Norman A. Crowder, and the "Linear Programming" of B. F. Skinner. Most current research is centering on linear programming. Results indicate that programmed instruction is successful in some applications, but not the answer to all training problems. The future may see an integration of programmed instruction and other training techniques within a systems approach to training and education.

180. Abma, J. S., *Theory and Research in Programmed Instruction,* AMRL Memorandum P-74, June 1964. AD 602 056.

Programmed instruction may be implemented within a systems approach to education. The system provides for feedback loops which permit modification of training materials on the basis of known effectiveness. Measurement is a crucial consideration in assuring that a given course or method is effective. Theories of learning and programming suggest many ways to proceed. Only applied evaluative experimentation can determine the usefulness of a given approach. Adjunctive, intrinsic and linear programming are discussed. Experiments call into question some current applications of features based upon theory, such as overt responding and reinforcement. It is possible to automate the various approaches to programmed instruction.

181. Abma, J. S., *Research on Programmed Instruction at the Behavioral Sciences Laboratory,* Wright-Patterson Air Force Base, Ohio, AMRL Memorandum P-63, June 1964.

The Training Research Division has conducted a number of studies of programmed instruction in the past several years, and has several studies currently underway. These studies are briefly summarized and described. Although programmed instruction is a changing field, future issues that probably will be of interest are listed. This research program may well have an important influence on future technical training techniques.

182. Andresen, K. W., and Ewing, D., *A Study of Digital Computers for a Real Time Training Simulation Research System,* AMRL Technical Documentary Report 64-22, May 1964. AD 601 649.

In the study phase of the project to provide a general purpose laboratory facility for use in research in training simulation techniques, digital computer systems and interface equipments were evaluated for the application. Criteria for the system evaluation were obtained from previous studies, involving the F-100A aircraft and EROS vehicle flight simulations using the UDOFT computer facility. Requirements for the computer hinge on a real time operating capability which stresses high computation rates. Significant characteristics include: 1. An operating rate in excess of 75,000 instructions per second on flight simulation problems, 2. A memory capacity of at least 8,000 words, 3. A computer word length of at least 24 bits, and, 4. At least three index registers. The result of the study phase is a recommendation of the Packard Bell 440 as the central computer of the simulation system; and as an alternative, a recommendation of the faster SDS 9300 computer is made provided its higher cost and later delivery time are acceptable. The recommended interface equipment will include a multiplexed analog-to-digital conversion subsystem capable of digitizing 32 input channels to 12 bits at a rate in excess of 35,000 conversions per second, a dual resolution digital-to-analog conversion system supplying 64 analog outputs to analog equipment, 72 sense inputs, 72 control inputs, and a digital interval timer.

183. Askren, W. B., "A Review of the Activities of the Air Force Personnel Subsystem Working Group." Paper presented at the meeting of the American Psychological Association, Los Angeles, September 1964, *American Psychologist*, Vol. 19, 1964.

The activities of the Air Force Personnel Subsystem Working Group are reviewed. The Working Group was chartered by the Air Force to provide guidance to its human factors efforts in developing new systems. The Working Group is subdivided into three panels to guide more closely the system development activities of human engineering, life support, and personnel and training. The work of the Life Support, and the Personnel and Training Panels is reviewed briefly. The work of the Human Engineering Panel is discussed in some detail.

184. Askren, W. B., "The Usefulness of Personnel Subsystem Data to System Development." In Benson, S.D. (Chairman), the Utility and Need for Extensive Documentation in the Air Force Personnel Subsystem Program. Symposium presented at the American Psychological Association, Los Angeles, September, 1964, *American Psychologist*, Vol. 19, 1964.

The terms data, personnel subsystem data, system development, and usefulness are defined. Data to the Air Force includes all engineering and logistic source information and documentation derived through a complete weapon system. Personnel subsystem data includes management data, product data and test data. System development is defined as the phases of requirements, design, fabrication, and testing. The important factors which determine the usefulness of data to a system are development cost, development schedule, impact on engineering decisions, and impact on system capability. The usefulness of personnel subsystem product data to engineering decisions during the design phase is explored in depth.

185. Barton, H. R., Purvis, R. E., Stuart, J. E. and Mallory, W. K., *A Queuing Model for Determining System Manning and Related Support Requirements*, AMRL Technical Documentary Report 64-21, January 1964. AD 434 803.

Increasing need for earlier estimates of manning, skills and training requirements led to the development of mathematically sophisticated techniques capable of computing and assessing requirements at every phase of system development. Current methods are largely intuitive, rely on bookkeeping procedures, and are seldom applicable at pre-hardware stages of system development. Needed was a method for making trade-offs when investigating alternatives in system design. The method presented here begins with an analysis of hardware functions and develops human requirements in terms of operational needs and service rates. Manning and skill requirements are integrated over such factors as desired operational readiness, schedules of mission frequency, various environmental demands, maintenance concepts and procedures, and training requirements. Two mathematical techniques, queuing theory and linear programming, are used to compute manning requirements and training needs. In practice, failed systems or units pile up in lines waiting for service, or else men are incompletely utilized. Queuing tables permit tradeoffs between men, skill levels, sparing levels and downtime with given values for operational readiness. The Simplex algorithm permits trade-offs and optional determination of training needs for given policies of phaseover and training cost. An advantage of the method is that its formal and mathematical structure permits objective assessment of all stages of system development.

186. Csanyi, A. P., Glaser, R., and Reynolds, J. H., *Programming Method and Response Mode in a Visual-Oral Task*, AMRL Technical Report 64-129, December 1964. AD 614 014.

Programming methods and response modes were investigated to determine effective training methods. The identification and pronunciation of phonetic symbols were taught by two different programming methods and two different response modes. The programming method featured either prompting or confirmation, and the response mode was either overt or covert. Achievement was measured on both a multiple choice test and a test requiring overt oral responses. Considerable variation occurred among the test scores for each learning condition. Differences among the conditions, tending to indicate the superiority of overt responding and of confirmation, were significant on only one case. Overt responding was superior for retention when measured by tests requiring overt oral responses. The prompting method coupled with the covert response mode tended to produce poorer learning and retention than the other conditions, but it required only 30 to 50 percent as much learning time as the other conditions.

187. Eckstrand, G. A., *Current Status of the Technology of Training*, AMRL Technical Report 64-86, September 1964. AD 608 216.

This report represents a brief overview of the current status of the technology of training. The processes involved in designing a training system are arbitrarily analyzed into the following three areas: (1) determining training requirements, (2) developing the training environment, and (3) measuring the results of training. In each of these areas, an attempt is made to summarize and evaluate the adequacy of our technology. In a final section of the report, certain areas of research which appear to be especially promising are discussed.

188. Eckstrand, G. A., Neiberg, A. D. and Morgan, R. L., *A Further Study of the Influence of a Relevant but "Unused" Cue in Training Upon Transfer in a Positive Transfer Situation*, AMRL Technical Documentary Report 64-81, September 1964. AD 607 472.

This study was an attempt to assess the utility of a cue that was relevant but not used in the solution of a first task in the learning of a second task. The relationship was such that if something were learned about the relevant but "unused" cue, positive transfer would be expected to occur. In an earlier experiment, no positive transfer was found in this type of situation. The present study essentially duplicated the first but involved an important procedural modification. This modification was intended to rule out the possibility that subjects in the first study had been trained to disregard this relevant but unused cue. The findings of the present study support those of the earlier one. Even with the revised procedure, no transfer was shown from learning the first task to the learning of a second task on the basis of the cue that was originally relevant but unused.

189. Elliott, T. K. and Folley, J. D., Jr., *The Maintenance Task Simulator-1 (MTS-1): A Device for Electronic Maintenance Research*, AMRL Technical Report 64-99, October 1964. AD 608 745.

The Maintenance Task Simulator (MTS-1) is a low priced task simulation device, specially constructed for research on performance aids used in conjunction with electronic maintenance. The device can present many complex electronic control-display panel configurations. The control-display panel is composed of a variety of modules which may contain a control or display or be blank. The device also contains sensing and recording circuitry, which provides a time-referenced record of control positions and sequence of manipulations by the subject. The device can support such research as determining the various skills and concepts required by the technician in performing various levels of electronic maintenance and developing effective techniques for evaluating the proficiency of electronic maintenance personnel. The logical next step would be to modify the MTS-1 for research on malfunction isolation tasks, i.e., the portion of the troubleshooting task conducted behind the front panel, after localization has been done, up to, but not including, the point of replacing the defective component.

190. Foley, J. P., Jr., *Functional Fundamentals Training for Electronic Maintenance Personnel*, AMRL Technical Report 64-85, November 1964. AD 610 367.

A majority of the experiments reported in the literature concerning functional electronic fundamentals have applied the functional principles to training for a very limited and specific area of maintenance--in some cases to only one electronic equipment. The present experiment was designed to include the fundamental tasks and concepts applicable to all of the electronic communications specialties at the time of the study. The course was organized around specially designed trainers that incorporated the desired circuits and task requirements. Considerable well spaced maintenance practice was given using common test equipment, such as, vacuum tube voltohmmeter, signal generator, and oscilloscope. The curriculum development principles and procedures as well as the results of controlled experiments are found in the report. The findings indicated that the traditional and experimental courses were equally successful in training high aptitude students (7, 8 and 9 stanines). The experimental course was much more successful, however, than the traditional course in training average aptitude students (4, 5 and 6 stanines). The job success of the average aptitude graduates who completed the experimental course was equivalent to that of the higher aptitude graduates.

191. Folley, J. D., Jr., Bouch, A. J. and Foley, J. P., Jr., *A Field Experimental Study of Programmed Instruction on a Manipulative Task*, AMRL Technical Documentary Report 64-90, October 1964. AD 608 296.

Approximately 1300 basic military trainees were used in a 3 x 7 factorial study of modes and content of training on a manipulative performance task, the assembly and disassembly of the M1 carbine. The modes of training included lecture-demonstration, a printed linear program with or without an answer sheet, and an audio-visual program presented by an audio-visual device or by a printed booklet. Also evaluated was a condition in which the trainees tried to perform the final task and were assisted as required. The content of the training was varied by providing training on assembly only, or disassembly only, or both. The final criteria were the time and the number of assists required to disassemble and assemble the M1 carbine. Although the modes of training differed significantly, the rankings were very different on the two criteria. No mode of training seemed clearly superior to the other modes. The audio-visual program presented in the printed booklet seemed somewhat inferior. Training on only the assembly of the carbine resulted in as good performance as training on both assembly and disassembly. The findings probably can be generalized only to relatively simple procedural type tasks. Replication of the study with more complex performance tasks is recommended.

192. Gael, S., "Problems in Evaluating System Manning Requirements Estimates and Estimation Techniques," *Journal of Human Factors*, Vol. 6, No. 3, June 1964.

System manning requirements information is desired prior to the time when it is scheduled to become available under the Personnel Subsystem concept. Rather than proceed from the conclusion that a new manning estimation method is needed to obtain manning information earlier, it is assumed that present methods can by used. Support for the assumption was to be obtained by validating manning requirements estimates for several systems, and assessing the adequacy of the estimation methods. Problems that arose in conducting the study are discussed. The shortcomings of the Mace B and the Bomarc manning requirements analyses are discussed along with the inappropriateness of system test data as criteria against which to evaluate manning estimates. The human factors system analysis approach, modified to account for pertinent quantitative data, is recommended for estimating manning requirements during the initial stage of system development.

193. Glaser, R., Reynolds, J. H., Harakas, T., Holzman, A. G. and Abma, J. S., *An Evaluation of Multiple Tracks in a Linear Program*, AMRL Technical Report 64-108, October 1964. AD 609 801.

Two experiments were performed to evaluate multitracking (branching) in a linear program. In experiment one, the multitracking consisted of providing additional cues at each frame for use by those students who felt unsure of their response. Results indicated no significant difference in efficiency between the regular linear program and the multitrack program. In experiment two, the multitracking consisted of large frames followed by more detailed frames whenever the student made an error. Large frames were developed by combining an average of three small frames. Again, the results indicated no difference in instructional efficiency between the regular linear program and the multitrack program. Although more errors were made on the large-step branching program, performance on criterion tests was as good as the regular small-step linear program. Although branching seems a reasonable way to accommodate individual differences, the two methods attempted in this research did not show an advantage. More promising methods of branching might be (a) less frequent branches, at critical points in the program, and (b) large-step frames followed by special remedial frames, rather than by mere repetition of parts of the original large frame.

194. Haines, D. B., *Training for Culture-Contact and Interaction Skills*, AMRL Technical Report 64-109, December 1964. AD 611 022.

Air Force participation in counterinsurgency (COIN) and pre-COIN missions requires a new emphasis in preparing the airman. Success in COIN depends upon the ability of the USAF individual to interact effectively with people in other societies. The cross-cultural training required differs markedly from the traditional Air Force stress on the operation and maintenance of hardware. Many USAF training missions abroad are short in duration and depend upon close, intensive interaction between the American advisor and his counterpart. These requirements make it necessary for the American to establish rapport quickly and to communicate efficiently with his counterpart. Up to the present it was assumed if the American were skilled in his job and in the language of the host country that with the correct motivation he could successfully carry out his mission. Such is not the case; skill is also required in the other person's customs, habits, taboos, mannerisms, and gestures. Traditionally, the American is prepared for these by briefings or lectures sometimes called "area studies." Unfortunately, knowledge about behavior does not guarantee skill in carrying out that behavior--knowing what to do is not the same as doing what you know. The report outlines a procedure for collecting in the field those cross-cultural behaviors most critical for the success of the advisory mission. A means of categorizing these behaviors for incorporation into a training program is described. These behaviors requiring passive knowledge may be easily taught by traditional lectures and handbooks. Other behaviors may be taught by programmed instructional materials while some require such subtleties of skill and motor facility that they require more elaborate teaching methods. A new method for teaching interaction skills through the use of a video tape recorder is also presented. Subjects are placed in a simulated cross-cultural situation requiring interaction skills known to be critical in the advisor-advisee relationship. They learn these skills through self-confrontation with video-aural playback of their behavior.

195. Harshbarger, J. H. and Gill, A. T., *Development of Techniques for Evaluation of Visual Simulation Equipment*, AMRL Technical Documentary Report 64-49, August 1964. AD 607 680.

Phase I of the research was a study of large area image display by projection television to evolve techniques of suitable image generation for astronautical flight simulation training. It was necessary to develop a technique to evaluate projected images. The display provided by the research apparatus, the close-circuit television system from an F-151 Fixed Gunnery Trainer, was evaluated; and performance characteristics of the 7WP4 performance in an ultra-high resolution television system revealed the tube to be unsuited to high resolution service. In Phase II, the projector in the F-151 television system was converted from a conventional 525-line system to a high resolution 1029-line system. The 525-line format operated at 30 frames per second, with a horizontal scanning frequency of 15.75 kc and a vertical scanning frequency of 60 cps. In the 1029-line system, the frame rate and vertical scanning frequency were retained, but the horizontal scanning frequency was changed to 30.87 kc. The vertical sweep generator, sweep protection, and projection control circuits were duplicated; a video amplifier and horizontal sweep generator were developed; and a volume of the control equipment was reduced from 144 to 32 cubic feet. Performance of the 7WP4 tube exceeded the prediction; limiting horizontal resolution is 650 to 700 lines with a well defined vertical raster. Results indicate that a study of basic CRT characteristics is in order, particularly for use in display devices.

196. Johnson, K. A., *The Effects of Test Trials on the Learning of Paired Adjectives*, AMRL Technical Report 64-105, October 1964. AD 609 317.

Three experiments were conducted to determine the extent to which blocks of test trials contribute to the learning of paired adjectives. The results were compared to those found in an earlier study of the relative effectiveness of various modes of the Subject Matter Trainer. The earlier study indicated that learning by means of the Quiz Mode, under conditions in which blocks of trails in the Quiz Mode were alternated with blocks of test trials, was considerably superior to learning by means of several other modes, none of which involved test trials. In the present experiments, it was found that the addition of blocks of test trials to blocks of learning trials led to improvements in learning. This was true whether learning was by means of prompting or anticipation trials. The improvements were comparable in magnitude to the trial-by-trial differences found between the Quiz Mode and two of the remaining modes used in the previous study. Apparently, much of the trial by trial advantage of the Quiz Mode in the earlier study was due to the use of test trials interspersed between learning trials. Other evidence, however, indicates that when subjects are allowed to pace themselves, the Quiz Mode will lead to a considerably greater amount of learning in a given time than any of the other modes of the Subject Matter Trainer.

197. Levine, M., Morgan, R. L. and Neiberg, A. D., *The Influence of First Task Practice and Intertask Similarity on Transfer of Training in a Symbol Substitution Task*, AMRL Technical Report 64-96, October 1964. AD 608 598.

This experiment investigated the effects of degree of learning of a first task and degree of similarity between two tasks on the transfer of training from the first to the second task. The basic relationship between the two tasks was such that learning the first might well interfere with learning the second. Twelve groups of 15 college students learned a symbol substitution task to one of four levels of mastery. They were then transferred to a task where the symbols in task I were rearranged to permit three degrees of intertask similarity. Extensive and persistent negative transfer was obtained. During the initial stages of learning task II, negative transfer seemed to decrease as the degree of learning of task I increased. However, during the later stages of task II, negative transfer seemed to increase with an increase in the degree of learning of the first task, especially with the higher degrees of learning of task I. The intertask similarity variable appeared to be significant only during the early stages of learning the second task. These findings differ from previous findings in the extent and persistence of negative transfer and in the tendency for it to increase with higher degrees of first task mastery. The present findings question the generality of existing transfer principles derived from slowly paced tasks involving relatively few discrete stimuli and responses.

198. Levine, M., Senders, J. W., Morgan, R. L. and Doxtater, Louise. *Tracking Performance as a Function of Exponential Delay and Learning*, AMRL Technical Report 64-104, November 1964. AD 609 811.

Eighty subjects performed a one-dimensional compensatory tracking task for 55 one-minute trials. The subjects were divided into five separate groups and each group performed the task with a different exponential delay between the control input and the display, a dot of light on a cathode ray tube. The time constants for the exponential delays were 0.015 seconds, 0.150 seconds, 0.900 seconds, 2.100 seconds and 3.000 seconds, respectively. The results indicate that times-on-target scores decrease with increasing delay. For delays greater than 0.150 seconds, the decrease is linear. There is a sharper decrease in performance from 0.015 seconds delay to 0.150 seconds delay than for other portions of the function. Increased practice changes the level, but not the shape, of the total function. The effects of delay and learning were within the same range, indicating that a given level of system performance often can be achieved either by altering the delay or by training the operator. However, performance is maximized if delay is reduced and the operator is trained.

199. Pask, G., "Self-Organizing Systems Involved in Human Learning and Performance," *1963 Bionics Symposium 19-20-21 March, Information Processing by Living Organisms and Machines*, ASD Technical Report 63-946, March 1964. AD 435 982.

This report compiles papers presented in the invited sessions at the Bionics Symposium 1963 held 19-21 March 1963 at Dayton, Ohio. These sessions are devoted to the subject Information Processing by Living Organisms and Machines and have the following titles: I. General Session; II. Signal Reception by Living Organisms; III. Information Processing By Living Organisms; IV. Physical Principles of Bionics; and V. Application of Bionic Concepts. Biological, mathematical, and engineering papers are equally represented attacking the problem of understanding and simulating the sophisticated information processing capabilities of living organisms by artificial means.

200. Purvis, R. E., McLaughlin, R. L. and Mallory, W. K., *Queuing Tables for Determining System Manning and Related Support Requirements*, AMRL Technical Report 64-125, December 1964. AD 458 206.

There has been a need for a method to quantitatively predict manning requirements of various system designs, and especially within any one design to depict the probable interplay between such system elements as personnel, operational performance, and logistics support if that design is developed. This report contains queuing tables which were developed to be directly applicable to characteristics of military systems having quantitative spares, personnel, component failure rates, and operational readiness performance requirements. The tables provide a ready means of estimating the performance capability of a complex system which depends upon capabilities of distinct support units. The tables also provide a manual means of performing tradeoff analyses between personnel, logistic support components, test equipments, component reliability and maintainability, and the number of systems to be supported. Examples of the practical applications of the tables are included.

201. Reynolds, J. H., Glaser, R. and Abma, J. S., *Learning Set Information in Programmed Instruction*, AMRL Technical Report 64-114, November 1964. AD 609 802.

Two different orders of three units of programmed instruction were administered to groups of students matched on (a) intelligence or (b) relevant achievement tests. Comparisons were made between groups that were (a) high or (b) average on each matching variable. The hypotheses being tested were that after varied amounts of prior practice in programmed instruction, (a) learning set formation would not be demonstrated by the high intelligence and high achievement groups, and (b) learning set formation would be demonstrated by the average achievement groups. Only partial support was obtained for each hypothesis. The data indicated the following: (a) In a programmed sequence, error rate is a more appropriate measure than achievement for observing learning set formation. (b) Learning set formation is observable in programmed instruction for all learners regardless of individual differences. Since reduced error rate was the indication of learning set formation, the phenomenon can be measured only in programs involving a moderately high error rate. (c) Since error rate differed for some of the experimental groups while achievement remained the same, the results were interpreted to mean that a moderately high error rate program which offers opportunity for correction of response errors may be as effective in producing learning as a low error rate program which confirms correct responses.

202. Reynolds, J. H., Glaser, R., Abma, J. S. and Morgan, R. L., *Repetition and Spaced Review in Programmed Instruction*, AMRL Technical Report 64-128, December 1964. AD 612 738.

The effects of repetition and spaced review in programmed instruction were studied. Experiments 1 and 2 covered a one-semester course in General Science at the Junior High School level. In Experiment 3, a 1280-frame portion of the total course was used. In Experiments 1 and 2, comparisons were made among (a) a conventional course, (b) a regular linear version of the program, and (c) a spiral version of the program. The results indicate that the programmed course was at least as effective as the conventional instruction in terms of both learning and retention after 15 weeks. The linear program was superior to conventional instruction on some measures. The spiral program offered few, if any, advantages over the regular linear program. Experiment 3 allowed a more precise evaluation of the separate effects of repetition and spaced review. Spaced review produced significant increases in learning which persisted, and even increased through a 3-week retention interval. Repetition did not produce increased learning or retention. The general conclusions are: (a) repetition of instructional materials above the usual level in a linear program is not beneficial; (b) spaced review is potentially beneficial; and (c) some techniques of obtaining spaced review, e.g., spiral programming, may offer disadvantages that equal or outweigh the potential advantages of spaced review.

203. Senter, R. J., Neiberg, A., Abma, J. S. and Morgan, R. L., *An Evaluation of Branching and Motivational Phrases in a Scrambled Book*. Technical Report AMRL-TR-63-122. November 1963. Also published in *Programmed Learning*, London: Sweet & Maxwell, Ltd., pp. 124-133, November 1964. AD 429 459.

This study evaluated three experimental versions of the scrambled text "The Arithmetic of Computers" by Norman A Crowder. The three versions were: (1) Unmodified, (2) Modified by deletion of motivational phrases, and (3) Straight Line having neither motivational phrases nor branching. Results showed no significant differences in amount learned or in study time.

204. Snyder, M. T. and Eckstrand, G. A., "Military Spacecrew Training," paper presented at meeting of American Psychological Association in Los Angeles, September 1964, *American Psychologist,* Vol. 19, 1964.

Training concepts were formulated based on an analysis of the human tasks, sharing sequences, stress tolerances, personnel positions, and skills required at detecting, monitoring, tracking, decision making, and communicating in performance of these tasks during hypothetical missions. From these data, functional characteristics of training devices for teaching the skills and knowledges were examined with emphasis on the requirements for feedback to trainees, degree of simulation, instructor stations, and the recording of student proficiency.

205. Stackfleth, E. D., *Test and Evaluation of Qualitative Personnel Requirements Information,* AMRL Technical Documentary Report 64-65, September 1964. AD 607 781.

Some of the problems in the validation of personnel requirements developed and predicted in the Qualitative and Quantitative Personnel Requirements Information reports are described. Included are problems inherent in the validation procedures, such as the nature of the predictor (QQPRI), the problem of criterion selection and bias, and the changing nature of the criterion. Because of the multiple nature of these problems, available testing techniques are not adequate to handle the testing and provide desired information. A solution is presented. This required a procedural change whereby validations are conducted during different but specific stages of system development and test. The validations would be oriented to obtaining the best validation at a particular time and for a particular purpose rather than attempting an overall test. Methods are suggested for determining manning deficiencies and readjusting the personnel subsystem.

206. Stolurow, L. M., *A Taxonomy of Learning Task Characteristics,* AMRL Technical Documentary Report 64-2, January 1964. AD 433 199.

The design of efficient training environments requires the selective uses of research findings from basic studies of learning. Decisions about the use of particular principles of learning are constantly required in the development of new training materials, systems, devices, and aids. Consequently, there is a critical need for a system of classifying learning tasks which will permit training specialists to make efficient use of principles of learning. This report is designed to assist a training specialist in the design and development of effective training programs in support of Air Force positions.

It presents a system for classifying learning tasks which was developed under this contract for the purpose indicated. The research and analytical procedures are summarized along with the findings produced by a tryout of the system with a group of training specialists.

207. Welch, J. C. and McKechnie, D. F., *A Preliminary Study of the Effects of Briefing Levels on Reconnaissance Performance with Side-Looking Radar*. Technical Report AMRL-TR-64-101, October 1964. AD 608 887.

Sixteen Air Force navigators were tested, after appropriate training, on four strips of side-looking radar imagery. The imagery, at a scale of 1: 197,000, moved across a back-lighted 14- by 14-inch screen at 3.3 inches per minute--corresponding to 500 knots. The subject's task was to identify all airfields, bridges, tank farms, power lines and railroad yards. The speed and accuracy of locating and identifying these targets under four different levels of briefing were assessed. The four briefing levels were: none, 10 minutes study of the corresponding chart prior to the simulated flight, access to the chart during but not prior to the flight, 10 minutes study of the chart prior to the flight and access to it during the flight. Fifty-six percent of the targets were correctly identified. On the average the target traveled 3.1 inches (56 seconds) after first appearing on the screen before being identified. False positive responses averaged 30%. The briefing compared, however, had no significant differential effects on the speed and accuracy of identifying targets or on the number of false positives. This should not be interpreted to mean that briefings will not be required for a side-looking radar. It does suggest that new briefing techniques and materials will need to be developed.

ABSTRACTS FOR 1965

208. Bush, Wilma Jo., Gregg, Delores K., Smith, E. A., and McBride, C. B., *Some Interactions Between Individual Differences and Modes of Instruction*, AMRL Technical Report 65-228, December 1965. AD 631 138.

This study explored the hypothesis that there is a relationship between patterns of learning ability and the amount learned in different instructional conditions. Scores for each of 44 subjects were obtained on (a) the Reading Vocabulary and the Mathematics Fundamentals subtests of the California Achievement Test, (b) the Administrative and the Mechanical Scales from the Airman Qualifying Examination, and (c) the Verbal and Performance Scales of the Wechsler Adult Intelligence Scale. Each of the 44 subjects were required to accomplish certain learning in five different situations. Differences between scores on associated subtests. (e.g., Reading Vocabulary minus Mathematics Fundamentals) were correlated with the difference between gain scores obtained in the various learning situations. A significant relationship was observed between the difference on the subtests of the California Achievement Test and the difference between the gain score from lecture-like instruction and the gain score in laboratory-like instruction. The data tended to support the hypothesis that students with relative strength in Reading Vocabulary are superior to students with relative strength in Mathematics Fundamentals when both are required to learn from instructional conditions that are highly verbal. On the other hand, students exhibiting relative strength in Mathematics Fundamentals tend to learn more efficiently in individual laboratory situations than do students showing relative strength in Reading Vocabulary. No comparable patterns were revealed relative to the scores from the Wechsler Adult Intelligence Test and the Airman Qualifying Examination.

209. Connelly, M. E. and Federoff, O., *A Demonstration Hybrid Computer for Real-Time Flight Simulation*, AMRL Technical Report 65-97, June 1965. AD 618 706.

A hybrid, real-time simulation facility has been designed, constructed, and demonstrated, using as a test vehicle the complete aerodynamic and engine equations for a high-performance military aircraft. The analog-digital configuration employs peripheral analog equipment to represent a linear, skeleton version of the aircraft and the PDP-1 digital computer to carry out engine simulation, decision management, and corrections for nonlinear effects. To provide an all-digital reference against which the hybrid simulation could be compared, the aircraft model, which in general scope is identical to the F-100A model used in the UDOFT studies, was also simulated on the PDP-1 alone. It was found that the solution rate of 20 per second employed in the all-digital study could be reduced to one per second without deleterious effects when the hybrid configuration was used. Such a reduction demonstrates that supplementing a digital computer by relatively inexpensive analog peripheral equipment in the manner suggested in this report substantially increases the real-time capacity of the digital computer in complex simulation applications. Moreover, because a number of key variables are computed continuously in the analog domain, the introduction of analog equipment results in a net decrease in the complexity of the interface, particularly in the number of analog storage devices required. The solid-state analog subsystem, designed and built at M.I.T., represents an order of magnitude reduction in cost and size relative to commercial analog computers of equivalent capacity. This improvement is largely due to a novel photoresistive multiplier developed by the project. Wide-bandwidth analog elements used on a time-shared basis are employed at the interface to generate running sums of products. This capability, however, is not an essential feature of the present hybrid concept. This report presents a detailed description of the hybrid design, the F-100A model, the system components, the PDP-1 programs, and the test phase. Tutorial discussions of scaling, key algorithms, model making, logical design, and the state-of-the-art in hybrid components are also included.

210. Eachus, H. T., *Self-Confrontation for Complex Skill Training, Review and Analysis*, AMRL Technical Report 65-118, September 1965. AD 624 062.

A review of the literature on self-confrontation and related phenomena was conducted to investigate the feasibility of their use as training techniques. The phenomenon of self-confrontation is the feedback of an individual's performance in a given situation through the use of video tape or sound motion picture film. This technique provides complete feedback of information and generates a situation in which subjects are quite amenable to modifications of their behavior, both verbal and nonverbal, with respect to given standards. The body of technical literature dealing with self-confrontation is small but complete enough to provide a basis for discussion of the phenomenon as a training technique. The analysis of the literature resulted in the recommendation for a research program to explore self-confrontation as a training technique for complex human skills.

211. Elliott, T. K., *The Effect of Format and Detail of Job Performance Aids on Performing Simulated Troubleshooting Tasks*, AMRL Technical Report 65-154, November 1965. AD 629 992.

The effects of performance aid format, performance aid detail, and subject aptitude on the performance of paper and pencil data flow analysis tasks were measured. Sixteen subjects were used in a 2 x 2 x 2 design. Eight of these subjects scored between the 75th and 95th percentiles on the electronic aptitude index of the Airman Qualifying Exam. The other eight scored between the 40th and 60th percentiles. Each subject received approximately 30 hours of training and practice, following which he was tested at one of the two levels of detail. Each subject was tested for 9 hours with aids in the block diagram format and for 9 hours with aids in the list structure format. Order of testing was counter-balanced across subjects. Criterion measures were: (1) number of problems attempted; (2) percentage of errorless localizations: (3) number of localization errors per problem; (4) number of localization errors of exclusion per problem and (5) percentage of errorless isolations. Subject aptitude was found to have the greatest effect on the accuracy with which subject performed both localization and isolation tasks. Level of detail had the greatest effect on their speed (low level of detail subjects solved nearly twice as many problems as high level of detail subjects). Performance was better with the diagrams than with the list structures. The only exception to this superiority was found on errors of exclusion, and then only for subjects working at the higher level of detail.

212. Foley, J. P., Jr., "The Requirements for Performance Tests for Measuring Training and On-The-Job Achievement," *7th Annual Military Testing Association Conference Proceedings*, 6570 Personnel Research Laboratory, 25-28 October 1965, pp. 69-77.

This paper is based primarily on AMRL Memorandum P-42, Performance Testing: Testing for What is Real, AD 412 776. The *official* objectives of formal technical training courses are to teach trainees to perform the specific tasks that make up the job for which he is being trained. However, the actual objective of many of these courses is to teach those behaviors that are tested by the course. It is generally conceded that performance examinations are superior to written examinations for the measurement of job behaviors required of Air Force specialists and technicians. However, performance examinations, both in school and on-the-job, are time consuming in their development and in their administration. Written examinations have, therefore, been substituted in many cases for performance examinations. This paper presents the difficulties involved in developing and administering performance examinations, the dangers of depending on written examinations as substitutes for performance examinations, and the fact that there is a lack of research information on the valid substitution of written examinations for performance examinations. It proposes developmental research with a view of simplifying performance examination procedures and establishing valid guidelines as to the scope of written examinations in measuring job performance.

213. Haines, D. B., *Training for Group Interdependence*, AMRL Technical Report 65-117, July 1965. AD 623 119.

Small teams and crews working together in intimate coordination are the key to many USAF missions today and effective team performance may depend upon member interdependency within the group. An adequate training program requires understanding of the ways in which men work together in closely knit groups. Goal and means interdependency in group process has long been a focus of interest for social psychologists. Current research and theory thus may provide useful guidelines for applications of group interdependency principles to military crew situations (particularly that of the American military advisory working with his foreign counterpart). The concepts of goal and means interdependency are defined, the controversy between current exponents of cognitive and stiumlus-response (S-R) theory is examined for its contribution to understanding group interdependency phenomena, the recent adaption of the theory of games is reviewed, and suggestions are made for the development of experimental training programs which will furnish insights into the nature of group functioning.

214. Haines, D. B. and Eachus, H. T., *A Preliminary Study of Acquiring Cross-Cultural Interaction Skills Through Self-Confrontation*, AMRL Technical Report 65-137, September 1965. AD 624 120.

An experiment was carried out to assess the relative effectiveness of two methods of training USAF military advisors in cross-cultural skills. A scenario was constructed requiring subjects to play the role of an American USAF Captain who had to interact, in specified ways with a "foreign counterpart," a role played by an actor. A list of 34 behaviors required ranged from actions, gestures, etc. which were similar to those in our own society, to those which were considerably different. Twenty-three male subjects were divided into control and experimental groups and taught the desired behaviors by two methods: (1) verbal coaching after a role playing session and (2) self-confrontation by a video tape replay after a role-playing session. Considerable improvement resulted from these methods. The experiment confirmed the effectiveness of self-confrontation as a training technique for the rapid acquisition of complex and subtle skills of interaction--an area of difficulty encountered by USAF advisors on counter-insurgency training missions. Suggestions for further research on self-confrontation as a training technique were made.

215. Hannah, L. D., Boldovici, J. A., Altman, J. W. and Manion, R. C., *The Role of Human Factors Task Data in Aerospace System Design and Development*, AMRL Technical Report 65-131, August 1965. AD 621 379.

On the basis of information gathered from generators and users of human factors task data by both interviews and questionnaires and by a review of relevant literature, human factors personnel and data were identified, the relations between them described, and recommendations for an automated human factors task data handling system proposed. Human factors personnel were clearly divisible into four hierarchically arranged groups: Program Level Manager, Personnel Subsystem Managers, Department Heads, and Nonmanagerial Personnel. In general, and for the populations described, managers and supervisors were the principal users and nonmanagerial personnel the principal generators of human factors data. A framework that permits classification of both formatted and unformatted data was proposed as responsive to the generally felt need by data generators and users for more orderly "book-keeping" in the human factors realm. Desirable characteristics of an automated human factors task data handling system were derived from the questionnaire responses. The responses also indicated that: (1) about 80% thought some use could be made of computers in their work, (2) retrieval time was important to at least 80%, (3) current model data retrieval times range from 1 to 6 days, (4) about half of the respondents were dissatisfied with current data retrieval times, and (5) retrieval times of less than 1 day would probably not be used more than twice a month be each respondent. Recommendations for implementing the system included steps necessary to design and apply it on a modest scale consonant with current system development.

216. Hannah, L. D. and Reed, L. E., *Basic Human Factors Task Data Relationships in Aerospace System Design and Development*, AMRL Technical Report 65-231, December 1965. AD 630 638.

The generation, use, and flow of human factors task data in aerospace system design and development are described. The data are characterized by a process of continual transformation in content and form of presentation occurring throughout the iterative cycles of system development. The networks within which data flow are shown to be extensive in size, pervasive in nature, and complex in their dynamic relationships. These dynamic processes are illustrated in flow diagrams showing the relationships of human factors task data and their input/output elements in functional analysis for planning, specifications, task analysis, human engineering, reliability, maintainability, qualitative and quantitative personnel requirements information, training equipment planning information, and maintenance manuals.

217. Harshbarger, J. H., *Test and Evaluation of Electronic Image Generation and Projection Devices, Volume I. Evlauation Techniques*, AMRL Technical Report 65-116 (I), August 1965. AD 623 908.

The report describes a method for evaluation of all types of displays in terms of resolution, brightness, and contrast ratio. The technique employs a television camera to replace human observation. This method thereby translates the characteristics of the display to measurable electronic waveforms. The waveforms are displayed on an oscilloscope where they may be analyzed directly and photographed, thus providing known standards of measurements in terms of electrical units rather than depending upon human judgment as a comparison standard. Direct evaluation may be applied to any display. The observer television camera furnishes data which are an expression of the display fidelity. Brightness is measured by a photometer. These terms are subsequently interrelated in an expression of the contrast ratio attainable at various resolution and brightness levels. The analytical evaluation, especially applicable to cathode ray tube (CRT) displays, obtains data through examination of the minute scanning spot as it traverses the image area. Analysis of the beam spot behavior enables one to predict the ultimate CRT capabilities without generating a complete display. Results of the direct method apply to the full display. These methods of evaluation are adaptable to displays of every type as standard measurement technique.

218. Harshbarger, J. H., *Development of a High Resolution Research Television System*, AMRL Technical Report 65-235, December 1965. AD 630 941.

As a basis for the evaluation of high resolution television displays for their possible application to visual simulation training, a television system was developed to provide high quality signals to drive the display devices which were to be evaluated. As a result of previous research, a 1029-scanning line television system had been developed. Limitations in this single camera arrangement restricted the research which could be conducted into high resolution devices. A larger, higher quality system was required to carry the research study to greater levels of performance with less effort lost due to maintenance and adjustment. The system constructed combines newly purchased devices modified as required for the application together with some specially developed items and other Government furnished equipment which was modified and integrated into the system. The design approach which led to the particular system concept employed is explained. The equipment itself is described in detail with schematics and interconnection diagrams provided for special pieces of equipment. The effort is considered successful, as documented by photographs of displays achieved through the system.

219. Harshbarger, J. H. and Basinger, J. D., *Test and Evaluation of Electronic Image Generation and Projection Devices, Volume II, Evaluation of Television Systems*, AMRL Technical Report 65-116 (II), November 1965. AD 628 693.

This report presents data from an evaluation of the 7WP4 Projection Cathode Ray Tube (CRT) operated in the high resolution mode of 1029-line scanning configuration to produce a suitable display for simulation training. The capabilities of the CRT were first predicted by theoretical analysis conducted while the tube was in actual operation, then the actual display was analyzed to confirm the theoretical predictions. The test image projected on a screen was viewed by an observer television camera to reduce the displayed image to electronic waveforms which formed the basis for an accurate evaluation. The results obtained during the practical evaluation of the CRT in all ways confirmed the theoretical predictions. The CRT showed a resolution potential greater than the 800-line prediction, with a high level of brightness, and adequate grey scale linearity. Spot size was found to vary inversely with the scanning speed; line width was reduced at the faster scanning rates. Resolving capability, limited by spot size, is shown related to both brightness and scanning. Also included in this report is data from the evaluation of a monochrome Schmidt projector and a color Schmidt projector. These projectors were subjected only to a Direct Evaluation; no special operating conditions or modifications were used. In both cases, the projectors were evaluated for video amplifier characteristics and geometric precision of the display. The display resolution was measured by use of the observer television camera technique, and the brightness of the display was measured. Results are presented in a graphic manner showing resolution versus display brightness that may be expected from either device.

220. Harshbarger, J. H. and Basinger, J. D., *Test and Evaluation of Electronic Image Generation and Projection Devices*, Volume III. *Evaluation of Projection Screens*, AMRL Technical Report 65-116 (III), December 1965. AD 630 659.

This report presents data from an evaluation of seven types of projection screen surfaces to determine which surface best meets the requirements of visual simulation for astronautical flight training. In order to evaluate the various screen surfaces in terms of their brightness and the angle through which incident light is reflected, methods of measurement were devised which compared each screen to a given reference surface. Two materials were tried as the reference surface, the traditional matte white surface of magnesium carbonate and a special type of white paint applied to masonite. The latter surface reflected the more uniform pattern of light, but proved difficult to duplicate due to the great care needed to apply the paint evenly. Thus the report recommends continued use of magnesium carbonate surface as the standard reference for display screen measurements. The test data on the seven screen surfaces indicates a wide variation in display characteristics. Apparently the user must accept an appropriate compromise between brightness and viewing angle--the more confined the viewing angle the brighter the display. It was also noted that flaws in the screen surface are particularly apparent in the more directive, brighter screen materials. It is thus essential that screens employing such materials be manufactured with extreme care.

221. Izzo, L. L. and Cubberly, H. A., *Optical Spot Size Study for Data Extraction from a Transparency.* AMRL Technical Report 65-175, September 1965. AD 628 588.

A breadboard model scanner using coherent light to generate a small optical spot for data extraction from a transparency was constructed. Using the technique developed, a capability of distinguishing 256 lp/mm and 30 shades of grey from light to dark was demonstrated. The system consists of a laser light source, a beam expander, a beam normalizer, a rotating optical scanning system to cover a 2-inch wide transparency, a transparency holder, a light collector and a photomultiplier assembly including video amplifier and high voltage power supply. These system components are basically "off-the-shelf" items.

222. Jacobs, J. N., Johnson, K. A. and Abma, J. S., *An Evaluation of Programmed Instruction for Teaching Facts and Concepts,* AMRL Technical Report 65-222, December 1965. AD 631 414.

This study evaluated five methods of teaching an academic topic ("Bill of Rights") to high school classes. The five methods were: (1) linear program in class, (2) linear program as homework plus discussion in class, (3) text version of linear program in class, (4) text version of linear program as homework plus discussion in class, and (5) conventional lecture-discussion method in class. The linear program alone provided the best results when measured both for the learning of factual material and general concepts about the topic. The linear program was best for high, intermediate, and lower levels of scholastic aptitude.

223. Johnson, K. A. and Senter, R. J., *A Comparison of Forward and Backward Chaining Techniques for the Teaching of Verbal Sequential Tasks,* AMRL Technical Report 65-203, December 1965. AD 628 944.

Three experiments were conducted to determine the relative merits of forward and backward chaining in the learning of sequential (serial) tasks. Previous research with animals has indicated the superiority of backward chaining and this principle frequently has been proposed for human learning. In all experiments the materials consisted of lists formed from familiar items (numbers, letters, words) arranged in arbitrary sequences. In the forward-chaining technique the subject begins by practicing the first item in the sequence. Next he practices the first and second items, then the first, second and third items, and so on until he is practicing the entire sequence. In the backward-chaining technique the subject begins by practicing the last item in the sequence. He then practices the next-to-the-last items, then the third-from-last, next-to-last, and last items, and so on until he is practicing the entire sequence. In all three experiments, the forward-chaining technique was superior to the backward-chaining technique. In the first experiment, this difference was not reliable, but in each of the remaining experiments, it was.

224. Johnson, K. A., Senter, R. J. and Smith, F. W., *The Effects of Similarity and Repetition of Response Alternatives on Various Types of Paired Associate Learning*, AMRL Technical Report 65-214, December 1965. AD 633 059.

Previous research has shown that the simple simultaneous presentation of a stimulus term and the single correct response term is as efficient as any alternative training techniques that have been suggested for paired associate learning. The present investigation was an attempt to find learning materials for which the simultaneous presentation technique would be inferior to other techniques. Subjects learned a 40-item list of paired-associates under one of the four training conditions. In the One Alternative Prompt condition subjects saw only the stimulus term and the correct response term; no anticipation was required. In the Two Alternative Anticipation condition subjects saw two response terms, one correct and one a distractor; they were required to select one of these before being told the correct response. The Five Alternative Anticipation condition was similar to the Two Alternative condition, but four distractors were used instead of one. Subjects in the Five Alternative Prompt condition also saw five response alternatives, but the correct alternative was indicated immediately; no anticipation was required. Three training trials were given under one of the above conditions. All subjects were then transferred to a criterion series that consisted of three trials in the Five Alternative Anticipation condition. The simulus terms were the names of electronic circuits, the response terms, schematic diagrams of electronic circuits. Half the items had distractors that were very similar to the correct response term, the remaining half, distractors that were less similar. Half the items in each of these groups had distractors that were the correct response terms for other items in the list. The remaining items had distractors that were unique to a given item. The overall differences between training techniques were not large, but there was some indication that the Five Alternative Prompt condition was inferior to the remaining conditions. Interactions were found between training conditions and item types, but again the differences involved were not large. Separate comparisons on the various item types indicated that in no case was the One Alternative Prompt condition reliably inferior to any of the remaining conditions.

225. Keenan, J. K., Parker, T. C. and Lenzycki, H. P., *Concepts and Practices in the Assessment of Human Performance in Air Force Systems*, AMRL Technical Report 65-168, September 1965. AD 625 041.

The report describes the current practices and evaluative aspects of human performance assessment in Air Force Systems. The human performance test programs for thirty-four systems and subsystems representing the major types of systems (aeronautical, electronic, missile, and space) used by the Air Force are reviewed. For these systems, the major functional areas covered include: (1) Air Force policies, directives, requirements, and constraints concerning the development and assessment of system tests and human performance; (2) the behavioral sciences approach to, and technology for, assessing human performance; and (3) Air Force practices in assessment of human performance. Throughout, the systems context, within which human performance is conceived and evaluated, is emphasized. Consequently, the techniques within the behavioral sciences for examining human performance conceptually and empirically in the system test environment is a particularly practicable part of the report. The report is supported by many tables and charts, excerpts from test directives pertinent to human performance assessment, and approximately 600 categorized references.

226. Lakshmanan, T. K. and Munt, I., *Study of Electroluminescent Display Techniques and Evaluation of a Thin Film Cross-Grid Display Panel*, AMRL Technical Report 65-166, December 1965. AD 631 465.

A study was conducted of the state-of-the-art of electroluminescent display techniques applicable to simulation of onboard displays of future vehicles and displaying computer and/or video information for use in training devices. Various fabrication techniques were compared and the one with greatest potential for producing a high resolution, bright cross-grid panel, 9" x 9" with 258 x 258 lines was selected for fabrication and evaluated to determine operational characteristics and limitations. Some basic considerations were given to driving electronics to determine designs for maximum flexibility for computer generated inputs.

227. Lewis, B. N. and Pask, G., "The Theory and Practice of Adaptive Teaching Systems," *Teaching Machines and Programmed Learning, II: Data and Directions*, Robert Glaser (Ed), pp. 213-266, National Education Association, 1965.

The work reported in this chapter constitutes what is believed to be the only sustained attempt to apply the notions of cybernetics and artificial intelligence to teaching machines and teaching theory. Inevitably, many of the concepts discussed in this chapter are likely to be unfamiliar to other workers in the field of programmed instruction. To anyone not versed in the theory of artificial intelligence, the sections of this topic can hardly do more than give the general flavor of the approach. Nevertheless the approach is rich in possibilities and well deserving of further consideration.

228. Purvis, R. E., Mallory, W. K. and McLaughlin, R. L., *Validation of Queuing Techniques for Determining System Manning and Related Support Requirements*, AMRL Technical Report 65-32, March 1965. AD 615 436.

A program was conducted to establish the validity and reliability of a technique of mathematical modeling for predicting manning requirements for weapon systems. The model was based on AMRL-TDR-64-21, "A Queuing Model for Determining System Manning and Related Support Requirements," and AMRL-TR-64-125, "Queuing Tables for Determining System Manning and Related Support Requirements." The technique was applied to two systems; the F-105D fire control system (FCS), which presently is operational; and the C-141 system, which is scheduled for operation in the near future. The model prediction for the FCS, using field data for parameter estimation, yielded good results when compared with operational performance. Moreover, it was shown that the operational performance could be achieved by 34% less personnel than the manning set by the table of organization. The model prediction for the FCS, using conceptual data, resulted in substantially the same manning for the maintenance shop as that developed from the measured data; but, because maintenance concepts had been changed in the field, the number of flightline airmen was larger than the measured data. The manning prediction for the C-141 system, based on operational rates planned for the system and field data on the C-130 system, resulted in a prediction of 819 airmen in the organizational maintenance squadron and 476 airmen in field maintenance squadron. With the predicted manning it could be expected that an operational readiness of 78% could be maintained.

229. Quinlan, R. V. and Holmquist, J. A., *Unique Scan Closed-Loop Television System*, AMRL Technical Report 65-215, December 1965. AD 630 905.

In the Phase I portion of this effort, a study of display components and techniques was undertaken to determine a feasible method of implementing a closed-loop television system which does not have the objectionable line structure and false reference cues of a conventional raster scan TV system. The result of this study was the recommendation to design and fabricate a closed-loop television system employing conventional raster scan and additional vertical deflection signals to break up the line structure and produce a more nearly flat field. The additional deflection signals were to be sine waves of frequencies (1) in the range of 100 to 500 kilocycles and (2) approximately 20 megacycles. Phase II of this effort was the design and evaluation of the recommended system. The basic pickup device employed is an electrostatic vidicon operating in a hybrid mode and the display device is a dual deflection cathode ray tube (CRT). The raster scan is generated by means of the magnetic deflection components and the additional vertical deflection is applied to electrostatic deflection plates. The primary display parameters are 945 lines, 30 frames per second, two-to-one interlace; however, provision is made for operation at 525 lines, 60 frames per second, two to one interface. High frequency deflection was found to be the most effective means of reducing line structure. Low frequency sine wave deflection aids breakup of line structure but, in some cases, introduces objectionable effects such as moiré patterns and flicker.

230. Reed, L. E. and Wise, F. H., "Computerized Personnel Subsystem Information," *Proceedings of Air Force/Industry Data Management Symposium*, Ballistic Systems Division, Norton AFB, California, 28-30 September 1965, pp. 271-277.

Research leading to advanced methods for computer handling human factors task information generated during system development programs is discussed. These methods are presented in terms of a technical data management concept for storing, retrieving and processing human factors information in a Government/contractor environment.

231. Senter, R. J., *Review of Mnemonics and Mnemonotechnics for Improved Memory*, AMRL Technical Report 65-180, December 1965. AD 629 594.

A review was made of books on mnemonics and mnemonotechnics. These are techniques for improving the efficiency of memory. These books describe the effect on memory of common principles of learning, such as, motivation, attention, and rehearsal. They also illustrate the use of simple mnemonics, such as "ROY G. BIV" for remembering the hues of the visual spectrum. More extensive descriptions, however, are provided of more complex mnemonic systems, such as, the so-called "hook" or peg" systems. With the hook system, information in serial order is retained by aid of vivid, even bizarre, visual images. The information to be retained is incorporated into a visual image which had been previously associated with a number. The report includes some uses of these techniques and some personal observations and analyses. These techniques offer interesting possibilities for improving the retention of technical information. Research on these techniques probably would be profitable.

232. Senter, R. J., Abma, J. S., Johnson, K. A., and Morgan R. L., *An Experimental Comparison of an Intrinsically Programmed Text and a Narrative Text*, AMRL Technical Report 65-227, December 1965. AD 635 001.

This study compared three methods of instruction in binary and octal arithmetic, i.e., (1) Norman Crowder's branched programmed text, *The Arithmetic of Computers*, (2) another version of this text modified so that subjects could not see the instructional material while answering "branching" questions, and (3) narrative text version presenting the same content material. The principal behavioral measure was relative performance on a pre- and posttraining criterion test. The results indicated that prohibiting visual contact with instructional material while answering questions significantly increased the number of erroneous alternatives selected by the subjects, but did not significantly alter the amount of learning manifested nor the time necessary to complete training. The programmed instructional methods resulted in siginficantly greater improvement on the criterion test than was attained by using the narrative text. The time to complete instruction was significantly less with the narrative text version of the material. Although, in general, less informational content was imparted with the narrative text, the study time necessary *per unit improvement* was significantly *less* with that version. Records were kept of the number of "wrong answer" branches taken by the subjects receiving instruction via the branched programs. Only about 6% of the total possible "wrong" branches were actually taken. This suggests that branched programming may be wasted by virtue of providing a quantity of material that is never studied.

233. Siskel, M., Jr., Lane, D., Powe, W. E. and Flexman, R. E., *Intra-Crew Communication of B-52 and KC-135 Student and Combat Crews During Selected Mission Segments*, AMRL Technical Report 65-18, May 1965. AD 617 598.

An experiment was carried out to compare within-crew communications in B-52 and KC-135 aircraft during peacetime training flights as functions of crew experience and selected mission segments. Crew transmission and message rates were obtained from tape recordings of crew communications on the aircraft interphone system during takeoffs and bomb runs in the bomber and takeoffs and air refueling in the tanker. In each case, samples were obtained from student crew solo missions and from the combat crew training missions. On the basis of earlier work, it was hypothesized that as a result of their lower level of coordination, the less experienced student crews would have a higher rate of communication than the more experienced combat crews. In two of the comparisons, this hypothesis was confirmed while in two others it was not.

Because none of the differences were statistically significant, the results were discussed in terms of trends which were indicated and several unavoidable compromises in experimental control.

234. Stephens, M. W. and Michels, K. M., *Motivational Correlates of Individual Differences in Performance*, AMRL Technical Report 65-39, May 1965. AD 618 895.

A three-year program of research was directed at the development of "paper and pencil" measurement techniques that would permit the assessment of the potential "motivatability" of subjects in experiments concerning the effects of environmental stress of human performance. A largely empirical approach was used in this research. Performance measures of a large number of subjects on several different tasks were used as the criterion measures in item analyses of several personality inventory tests. The resultant pool of cross-validated items will, it is hoped, represent a step toward increasing the precision of performance research.

235. Taber, J. I., Glaser, R., and Schaefer, H. H., *Learning and Programming Instruction*, Reading, Massachusetts: Addison-Wesley, 1965.

The book was developed from an Air Force manual under the supervision of the Training Research Division. The text presents the underlying principles of behavior that are related to instructional programming as an aid in constructing, evaluating, and selecting programs. The authors also detail the most practical programming techniques currently in use. The major concepts and operations in learning and instruction as derived from the behavioral scientist's laboratory are described. Covered are the principles of behavioral psychology, methods for organizating subject matter for instructional purposes, techniques for writing program frames and sequences, techniques in program production, and research in the area of programmed instruction. The primary purpose of this book is to bring together basic principles of behavior with accepted programming methods in a form which may be easily used by educators, producers of educational and training material, and psychologists interested in programmed instruction and educational technology.

236. Trow, W. H. and Smith, E. A., *Filmstrip Techniques for Individualized Instruction*, AMRL Technical Report 65-78, May 1965. AD 617 607.

In the preparation of filmed programmed instruction, several considerations are involved in the choice between slides and filmstrips. In this report, the considerations of revision, quantity, length, storage, recycling, aspect ratio, change time, random access and continuous repetition are briefly discussed. A comparison of costs of preparing a master of the filmed program and duplicate copies is made. As a guide to the preparation of filmstrips by staff photographers, some of the problems involved are discussed, namely single-frame cameras, the preparation of flat copy, exposure and splicing. Other film formats with possible application in audio-visual programming are described.

237. Trow, W. H. and Smith, E. A., *An Examination of the Feasibility of Modular Design for Audiovisual Autoinstructional Equipment*, AMRL Technical Report 65-79, May 1965. AD 617 608.

The increasing need for audiovisual autoinstructional equipment in a wide range of applications has created a major problem in development of satisfactory equipment to meet the varying demands. Each specific situation requires a certain combination of optical, mechanical and electronic functions which cannot necessarily be adapted to subsequent usages of the equipment. This results either in the costly acquisition of many similar pieces of equipment or in undesirable restrictions on the instructional techniques that might be used. This study examines existing and potential areas of application for audiovisual autoinstructional equipment and proposes a modular approach in the development of new equipment. Each module would embody a separable major function and would be interchangeable in the system. The proposed basic modules would include: (1) a slide-changer module, (2) a filmstrip module, (3) a family of screen modules, (4) a family of light source modules, (5) an audio record and playback module, (6) three signal pulsing modules, (7) a multiple-choice response module, and (8) a write-in response module. Many of these would allow operational alternatives or modification for specialized applications for maximum versatility.

238. Trow, W. H. and Smith, E. A., *Design Considerations Influencing the Size and Cost of Optical Components in Auto-Instructional Devices*, AMRL Technical Report 65-80, May 1965. AD 617 609.

The increasing demand for low-priced projectors for self-instructional purposes has prompted investigation of design factors which contribute to the manufacturing costs in this class of product. Because cost and intended use are prime factors, design must be based upon the optimum combination of optical components which satisfies these design objectives. The problems of the projector design itself are considered, primarily the design considerations for optical components that might be used. Recent developments in lens and reflector fabrication methods do not yet permit a reduction of cost below that of conventional methods and designs. Some principles and practices for rear projection are presented, and the interdependence of major factors involved in maximizing screen performance is expressed in mathematical terms. The environmental factors of room illumination level, audience size and the contrast of the filmed material are found to be highly influential in the design of a rear-projection device.

239. Walther, R. E. and Crowder, N., *A Guide to Preparing Instrinsically Programmed Instructional Materials*, AMRL Technical Report 65-43, April 1965. AD 617 740.

To aid those responsible for the preparation of intrinsically programmed instructional materials, the procedures and techniques developed by the Educational Science Division of U.S. Industries, Inc., have been organized into a practical working guide. The organization of this report closely follows the sequence of steps required to produce an effective intrinsic program. Although other systems of programming are identified, this guide is specifically intended for use in the preparation of intrinsic programs in either book or Tutor Film format.

240. Whiteman, I. R., *The Role of Computers in Handling Aerospace System Human Factors Task Data*, AMRL Technical Report 65-206, December 1965. AD 631 182.

The characteristics of a computer based data system for handling human factors task information generated in support of advanced system development are described. On the basis of information gathered from users and generators of data at representative Government and contractor installations, the current and potential uses of computers were assessed to determine the desirable characteristics for a computerized human factors task data handling system. The proposed data handling system will assist the human factors specialist and system design engineers in the design and development of systems by providing them with means for: (1) drawing them closer to the data through a user-oriented system, (2) comparing data generated through the life cycle of an advanced system and across systems, (3) analyzing data and conducting man-machine simulations, and (4) insuring that data are made available on a selective query and a timely basis. These objectives are met within the framework of a data system concept referred to as CENTRAL. The functions of CENTRAL are: (1) data storage and retrieval, (2) data processing, (3) computer program maintenance, and (4) system operational manual maintenance. The forms of data to be housed within CENTRAL, the methods for storage, processing and retrieval, and the nature and configuration of the data handling are discussed. Recommendations are made for a follow-on prototype data handling system to be developed and exercised with actual advanced system data. The prototype system would be responsive to data which are best stored within the computer, and data which do not lend themselves to storage within a digital computer, such as data of a pictorial nature.

241. Wing, J. F. and Thomson, Barbara P., *Primacy-Recency Effects in Free Recall*. AMRL Technical Report 65-164, July 1965. Also in *Proceedings of 73rd Annual Convention American Psychological Association*, pp 57-58, July 1965. AD 629 902.

In this study primacy and recency were found to change as a joint function of rate of presentation and ordinal position of a list within a series of lists. The first list of a series produced greater primacy than recency at a slow rate (5 seconds) but the opposite at a fast rate (2 seconds). This was true for 10, 15, and 20 items lists. For subsequent lists of a series the curves showed greater recency at both rates and for all list lengths. These findings establish that serial-position curves averaged over many lists are not the same as curves based on a single list.

ABSTRACTS FOR 1966

242. Connelly, M. E., *An Analog Photoresistive Multiplier*, AMRL Technical Report 66-71, March 1966. AD 638 816.

An inexpensive, yet accurate, analog multiplier producing seven products of a common variable has been developed and tested successfully. The device utilizes resistance variations in an array of light photoresistive cells illuminated by a single incadescent lamp, the light level of which is controlled by the common multiplier. Three specific configurations are discussed in this report; two are four-quadrant multipliers and the third is a two-quadrant multiplier. The use of the latter in analog division is also treated. Static accuracies for the three configurations range from 0.1 percent to 0.25 percent relative to full-scale ±10 volts. The cell history, voltage, and temperature characteristics and the frequency response of the cell and lamp are discussed in detail.

243. Eachus, H. T., *Comparison of Various Approaches to Training for Culture-Contact*, AMRL Technical Report 66-7, March 1966. AD 635 382.

A comparative analysis of several approaches to training interaction skills for culture-contact was conducted. In addition, the range of American overseas work by the Air Force and other Government agencies was delineated with discussions of the type of training most required in different areas of involvement. Two major opposing scientific conceptualizations of training for culture-contact are discussed. The objectives of cross-cultural interaction skill training are presented with consideration of self-confrontation as a training technique.

244. Eachus, H. T. and King, P. H., *Acquisition and Retention of Cross-Cultural Interaction Skills Through Self-Confrontation*, AMRL Technical Report 66-8, May 1966. AD 637 719.

An experiment was conducted to assess relative effectiveness of two techniques for training United States Air Force military advisors in cross-cultural communicative skills. Retention of skills over time and effects of attitude on learning were also studied. A scenario required subjects to play the role of an Air Force captain who had to interact in specified ways with a "foreign counterpart," a role played by a confederate of the experimenters. Subjects were to perform 57 distinct behaviors appropriate to the situation and to the factitious cultural description, which gave either a positive, negative, or neutral impression of the culture. Sixty-six male subjects were divided into two groups and taught the desired behaviors whether by extensive reading of training manuals followed by three role-playing sessions or by less reading but with self-confrontation by a video tape replay between successive role-play trials. Subjects returned and performed the same role again either one day, one week, or two weeks following initial training. Self-confrontation proved superior to manual reading in training the desired behaviors. Subjects with positive attitudes toward the culture learned fastest. Retention of skills learned through self-confrontation was high. A discussion of planned future research on cross-cultural techniques and programs is given.

245. Eckstrand, G. A., "Improving the Technology of Training," *USAF Instructors Journal*, Vol. IV, No. 1, 38-45, Summer 1966.

This report describes the research and exploratory development programs of the Training Research Division. A brief sketch of the work performed by the various branches of the Division is presented. The areas of research covered are Operator Training, Technical training, Personnel and Training factors in systems design and simulation techniques.

246. Elliott, T. K., *A Comparison of Three Methods for Presenting Procedural Troubleshooting Information*, AMRL Technical Report 66-191, September 1966. AD 649 598.

The effects of subject aptitude and performance aid mode of presentation on the performance of procedural, between-stage troubleshooting tasks on a real piece of electronic equipment were studied. The study used nondecision aids presented in three modes, namely, an automatic retrieval of visual information, an automatic retrieval of audio information and a manual retrieval of visual information. Two aptitude groups (Air Force electronic index 40-60 and 75-95) with no previous electronic training or experience were given from 3 to 5 hours of task training before the experiment. Each subject solved 26 actual and 11 synthetic problems. The study indicated no difference in effectiveness of aids using visual presentations. Both were superior to audio presentations. The two aptitude groups were equally effective in performing troubleshooting tasks using nondecision aids. In comparison with a previous study using decision aids, the study showed nondecision aids produced superior performance on the same between-stage troubleshooting problems using similar subjects.

247. Foley, W. L., *A Study of Light Modulation and Scanning Techniques for Application to Simulation Display Generation*, AMRL Technical Report 66-9, March 1966. AD 637 307.

Various techniques for modulation and scanning of coherent light are analyzed for application to the generation of high contrast displays for simulation. A number of possible techniques are discussed in the main body of the report. The individual discussions include a brief description of the principles of operation together with capabilities relative to bandwidth, contrast ratio, deflection angle, alignment, sensitivity, ease of fabrication, and handling. This is based somewhat upon voltage and power requirements over range of operation.

248. Folley, J. D., Jr., Woods, R. H. and Foley, J. P., Jr., *Comparison of Three Modes of Instruction for Operation of a Complex Oscilloscope*, AMRL Technical Report 66-195, November 1966. AD 654 004.

A field experiment was conducted to compare the effectiveness of three modes of instruction in the use of the AF 1807 oscilloscope (Tektronix 545A). Skilled electronic technicians of the U.S. Air Force Security Service served as subjects. One group was trained with an audio-visual instructional program, and a second group with a book form of the same program. The program combined verbal instruction and responses with practice on an oscilloscope. A third group was trained in the manner normally used at the school where the study was conducted. Analysis of variance on test scores indicated superiority of both forms of the program over the conventional instructions with no difference in effectiveness between programs. Electronic aptitude, as measured by the Airman Qualifying Examination, correlated significantly with test scores for the conventionally trained group and for all subjects together.

249. Geiselhart, R., *The Effect of Prior Experience on Acquiring Skill on a Simulated Inertial Control Task*, AMRL Technical Report 66-25, July 1966. AD 641 389.

The performance of test pilots and college student subjects in acquiring the skill to control the attitude of a simulated space vehicle was compared. The purpose of the comparison was to investigate transfer of training to this type of task as a function or prior pilot experience and determine the degree to which one may generalize from students to pilots. There was also further breakdown of the student group into experimental subgroups to assess the effects of type of control/display relationship and the order of part training on the acquisition of the vehicular control task. The secondary comparisons within the student group were to determine optimal training conditions to make the comparison with the pilots as equitable as possible. The conclusions based on the results of the study were (1) there appear to be more positive transfer effects than negative in transitioning from flying aircraft to a simulated inertial control task; (2) the degree to which generalizations can be made from students to pilots depends on the amount of training given the students provided an optimal control/display relationship is used; (3) previously untrained subjects can achieve skill levels comparable to pilots on this type of task, but it takes more trials for the nonpilot to do so; and (4) order of part training does not appear to be an important variable in training on this type of task.

250. Ginsberg, R., McCullers, J. C., Meryman, J. J., Thomson, C. W., and Witte, R. S., *A Review of Efforts to Organize Information About Human Learning, Transfer, and Retention*, AMRL Technical Report 66-23, March 1966. AD 635 491.

In this report, 14 efforts pertaining to organizing available information on human learning, transfer, and retention are summarized and evaluated on six criteria: behavioral significance of categories, scope, objectivity and reliability of categories, prognosis for the system, logical structure, and heuristic value of the system. Attention is also given to several other sources of guidance for organizing information on human learning. The review indicates at least six major approaches to a taxonomy of human learning. The bases for these different approaches are: (1) general or limited theoretical factors, (2) conditions of learning including the learner, (3) individual differences, (4) physical characterisitcs of learning tasks, (5) task characteristics in relation to empirical variables, and (6) task characteristics in relation to learning principles. In some cases the approaches are combined. The major conclusion is that although some contributions have been made to a general organization of information on human learning, intense and detailed efforts toward a comprehensive taxonomy are only in a preliminary formative phase. An empirically grounded and logically sound taxonomy of a wide range of learning situations will contribute substantially to the use of existing information and to the guidance of future research.

251. Gum, D. R. and Knoop, Patricia, A., *Automated Input/Output Diagnostics for a Real Time Simulation Research System*, AMRL Technical Report 66-133, October 1966. AD 655 771.

This report describes a library of automated diagnostic test-programs for the real-time input/output section of a digital training simulation research system. The application of such automated tests to simulation-system acceptance testing is explored. Included is a description of real-time simulation as a training technique and the Real-Time Simulation Research Systems (RTSRS) for which the test-programs were prepared. Detailed program listings, flow charts, and abstracts of each test and of utility subroutines are also provided.

252. Harshbarger, J. H., *Color Signal Source for Visual Simulation*, AMRL Technical Report 66-116, September 1966. AD 645 140.

A specialized color closed-circuit television camera system was developed as a source of high-quality signals to be used in simulation display device research programs. The system employs three vidicon camera tubes in conjunction with a unique optical and beam-splitting system. Camera configuration permits the system to be used as a three-color pickup, a multichannel monochrome signal source, or a high performance monochrome television signal source. The camera system contains four major units: camera, camera control, video inverter, and power supply unit. The camera is mounted on a special framework which also serves as a model or test chart support. The camera control, power supply, and color television monitor are placed in a rack cabinet. Wherever possible standard circuit modules of high quality are employed in the system; this design approach provides a high degree of reliability even though the system represents a new approach to color television camera design.

253. King, P. H., *A Summary of Research in Training for Advisory Roles in Other Cultures by the Behavioral Sciences Laboratory*, AMRL Technical Report 66-131, September 1966. AD 648 517.

Due to the crucial need for improved interpersonal relations between United States Air Force technical advisors overseas and the indigenous persons with whom they work, a program of research has been established to improve methods for training cross-cultural communicative skills. This research is divided into four parts: (1) identification in the field of critical incidents and analysis of interactions between Americans and native persons; (2) development, testing, and evaluation of means of collecting information on other cultures; (3) development in the laboratory of new training methods for imparting the appropriate cultural skills; and (4) experimental training programs, using Air Force personnel in actual operational contexts. Each of these aspects is described, as is a major laboratory experiment. This study compared two training methods for teaching cross-cultural interaction skills. Subjects trained under self-confrontation (viewing video tape recordings of their performance in role-play situations) learned faster and attained a higher terminal level of performance than subjects who received a standard training manual to read. Subjects with positive attitudes toward the foreign culture learned faster than subjects with neutral or negative attitudes. Retention of skills learned through self-confrontation was high over a 2-week interval. A discussion of future research employing video tape and the self-confrontation phenomenon is given.

254. Knoop, Patricia A., *Programming Techniques for the Automatic Monitoring of Human Performance*, AMRL Technical Report 66-16, April 1966. AD 637 454.

This report describes the organizational and operational design of a digital computer program for the automatic monitoring of human performance during simulated training missions. The computer program, now in its development stage, is designed to serve the dual and interdependent purposes of (1) assisting in the analysis and determination of meaningful performance measures and performance criteria and (2) using these criteria to automatically monitor human performance, including performance evaluation (scoring), adaptive task sequencing, and the automatic initiation of simulated system malfunctions for training in emergency procedures. A description is provided of a Criteria Format that aids the user of the automatic monitoring program in defining criteria with variable tolerances for conceivably any aerospace task or mission. Some projections are made about possible uses of the research oriented automatic monitoring program to (a) vary criteria as the skill level of a particular student increases, (b) hold selected flight variables constant to allow the teaching of controlling the outputs to the cockpit, and (d) aid in debugging simulation programs. A topical flow-chart is provided for the entire automatic monitoring program.

255. Meyer, D. E., *A Comparison of Response Confirmation Techniques for an Adjunctive Self-Study Program*, AMRL Technical Report 66-98, June 1966. AD 640 503.

An experimental evaluation was made of various methods to confirm responses to an adjunctive self-study program. The adjunctive program was designed to teach aircraft engineering features of the F-101B as part of a continuing program of refresher training for operational fighter interceptor aircrews. The adjunctive program consisted of a comprehensive series of carefully sequenced multiple choice questions. Each question referred to the page and paragraph number of a publication containing detailed information on which the question was based. Responses to the questions were confirmed as being either correct or incorrect by one of the experimental treatments. When a student responded correctly be continued on to the next question, when he responded incorrectly he studied the appropriate information in the manual before continuing on with the program. The response confirmation treatments were (1) chemically impregnated inks which change color when moistened with a wetting agent, (2) punchboards, (3) opaque erasable overlays, and (4) machine presentation and response confirmation. The response confirmation treatments varied widely in cost and difficulties in preparation. Production procedures and a discussion of problems encountered are included in the appendices of the report. No significant differences in learning were found as a result of the experimental treatments, nor were there any notable differences between group opinions concerning the efficacy of the particular response confirmation method used. Upon this basis, the selection of a response confirmation mode for an adjunct program may be based upon cost and availability of equipment and materials.

256. Meyer, D. E., *Adjunct to Self-Study for Aircrew Refresher Training Under Operational Conditions in the Air Defense Command*, AMRL Technical Report 65-83, March 1965. Also in USAF *Instructors Journal*, Vol. IV, No. 2, 38-46, Fall 1966. AD 617 775.

This is a report of the development and experimental comparison of a self-study technique with conventional classroom methods as a means of refresher training of Air Crews under operational conditions. The self-study technique consisted of (1) a comprehensive series of multiple-choice questions covering the subject matter with each question bearing reference to the page and paragraph of a manual containing the detailed information on which the question was based, (2) a punchboard by which students immediately determined whether their answer to each question was correct or incorrect, and (3) the manual to which students referred for information when they chose an incorrect answer to a question. The conclusions are: (1) the preparation and administration of the self-study technique is entirely within the capability of an operational squadron with only a minimum of guidance; (2) in the operational setting, the self-study technique is superior to conventional classroom methods in its effectiveness as a means of refresher training; and (3) students favor the self-study method for refresher training.

257. Potter, K. W. Tulley, A. T., and Reed, L. E., *Development and Application of Computer Software Techniques to Human Factors Task Data Handling Problems*. Technical Report AMRL TR-66-200, December 1966. AD 647 993.

Research leading to the application of computer software techniques for handling human factors task data generated in support of aerospace system development programs is discussed. It is recognized that data handling techniques must be developed in context with their total operative environment. A concept of an operational data management system for storing, processing, and retrieving human factors task data in a government/contractor environment is discussed and illustrated. This concept is predicated on the assumption that a user-oriented computerized data system will help draw human factors specialists closer to their data. Five problem areas, considered to be fundamental to the development of data handling techniques, were researched. These areas are: (1) analysis of human factors task data, data relationships, and classification schemes, (2) application of vocabulary and thesaurus techniques to increase the effectiveness of communication among man/machine/software functions, (3) application of computer storage and retrieval techniques to human factors task data, (4) application of analytical and simulation techniques to human factors task data, and (5) application of current awareness techniques to provide notifications of data availability.

258. Smith E. A. and Senter, R. J., *Automated Readability Index*, AMRL Technical Report 66-220, December 1966. AD 667 273.

Inasmuch as the utility of technical manuals is influenced to a marked extent by their reading difficulty or readability, the Automated Readability Index was devised to provide an easy, automated method of collecting data from which textual material can be evaluated in terms of readability. Whereas most readability formulae include separate factors related to (1) word difficulty and (2) sentence difficulty, the Automated Readability Index provides for the mechanical tabulation of the required data on passages as they are typed on a standard typewriter. Impulses from the typewriter activate counters which record the number of letters, words and sentences contained in the passage. From this, the average word length and average sentence length are computed. Appropriate weightings of these factors result in an index reflecting the readability of the passage. This index is in close agreement with other indices of readability.

259. Smith, E. A., Williams, G. S., and Mohlman, H. T., *Goniophotometer to Measure Diffusion Characteristics of Rear Projection Screens*, AMRL Technical Report 65-207, December 1966. AD 631 315.

A goniophotometer has been developed for use in measuring the diffusion characteristics of rear projection screen materials. Rear projection screens provide a wide range of possible diffusion characteristics. Similarly, different applications require different characteristics. The goniophotometer will facilitate the selection of screens most suitable for a particular application. Primary components of the device include a light tight chassis, a light source mounted on an arm which can be rotated ±60°, a holder for screen specimens, a specifically designed photometer, and two interior ambient light panels and associated interior footcandle meters. Schematics, wiring diagrams, and drawings necessary for the fabrication of additional units are included.

260. Smode, A. F., Hall, E. R., and Meyer, D. D., *An Assessment of Research Relevant to Pilot Training*, AMRL Technical Report 66-196, November 1966. AD 804 600.

This report presents a critical review and interpretation of the considerable amount of research data that have either direct or indirect implications for the training of pilots. The purpose is to organize systematically the research findings from the human performance and the training research literature that are pertinent to pilot training, and, based on the status of research in defined areas, to identify research issues. Successive portions of the report deal with studies on the measurement, simulation and transfer of training, operational components of the pilot's job, and the maintenance of flying proficiency. In addition, attention is given to studies concerned with improving training systems and recent innovations in training methods are reviewed. As it provides a considerable background of information directly concerned with pilot training, this report will be of interest to individuals involved in any aspect of flight training.

261. Stoner, L. D., Horton, J. A., and Carson, E. R., *Simulation Image Generation: Study of Television Camera and Optical Pickup from Scale Relief Models*, AMRL Technical Report 66-18, Vol. I, February 1966. AD 485 304.

Simulation devices for high-speed low-level flight, approach, and landing are considered deficient in one or more of the areas of (1) depth of field, (2) resolution, (3) perspective, and (4) shading. Phase I of this study program is an investigation of these problems as they relate to an optical-pickup/three-dimensional-model/television-system type of visual-image generator. The problems are examined in detail, and solutions or optimization techniques are offered for advancing the state-of-the-art. Ten approaches - six with a single television channel in black-and-white and four in multiple-tube configuration, variously arranged for electronic data compilation of the equivalent high-resolution pickup plane are developed more fully; these are the recommended designs, representing state-of-the-art advances for improving depth of field. For available high-resolution television systems, it is possible to design a practical optical-pickup image generator whose apparent resulting display resolution is essentially limited by the television characteristics for all typical conditions of probe-model relationships and simulated vehicle attitudes.

262. Sullivan, H. J., Baker, R. L., and Schutz, R. E., *The Effect of Intrinsic and Extrinsic Reinforcement Contingencies on Learner Performance*, AMRL Technical Report 66-138, September 1966. AD 647 273.

Seventy-six AFROTC Cadets studied a revised version of the text, *The Military Justice System*, for four 50-minute class periods distributed over 2 weeks. Unit-mastery tests of 12 multiple-choice items each were administered at 11 points throughout the text. Half of the subjects (Cadets) received no knowledge of the correctness of their responses on the unit-mastery test. The other half of the subjects used chemically treated answer sheets which immediately indicated whether or not the subject's answer was correct. A 100-item mulitple-choice test over the text was administered to all subjects 2 days after the final instruction period. All subjects had been informed of the final test. Half of the subjects in each of the above groups had been assured payment of $2.50 for participation in the study. Each student in the other half had been told that he would receive $4.00 if he scored 80% or higher on the final test, $2.00 if he scored from 50 to 79% and nothing if he scored below 50%. Compared with other subjects, students using the chemically treated answer sheets completed the study of the text in less time and appeared to depend on the mastery tests for additional instruction. They performed significantly poorer on the unit-mastery tests. On the final criterion test, however, none of the groups differed significantly. Rather complex factors must be considered in specifying the optimal conditions of reinforcement and incentives.

263. Whitted, J. H., Jr., Weaver, E. E., and Foley, J. P., Jr., *Development and Experimental Evaluation on an Automated Multi-Media Course on Transistors*, AMRL Technical Report 66-142, September 1966. AD 646 671.

A completely automated multi-media self-study program for teaching a portion of electronic solid-state fundamentals was developed. The subject matter areas included were fundamental theory of transistors, transistor amplifier fundamentals, and simple mathematical analysis of transistors including equivalent circuits, parameters, and characteristic curves. The media included tape slide audio-visual presentations, a programmed text, a cued text, a sound movie, a workbook, and an RCA transistor trainer. A controlled experiment was conducted, comparing the effectiveness of the self-sufficient multi-media materials, with a conventional instructor/classroom presentation and existing self-study materials from Air Force Extension Course Institute. Even though the instructor/classroom subjects received somewhat higher ratio gain scores, on the average, than the multi-media subjects, this difference was not significant. Both of these modes were superior in effectiveness to the extension course materials. The principal measures of this effectiveness were a pre-test and a post-test made up of multiple choice items concerning the solid state theory covered.

264. Woods, R. H., Trudo, F. J. and Pieper, W. J., *An Instructional Program on Operation of the Tektronix 545A Oscilloscope*, AMRL Technical Report 66-81, June 1966. AD 638 328.

This report contains a 368 frame, book program, for teaching the operation of the Tektronix 545A Oscilloscope together with a response booklet and administrator's manual. The oscilloscope operations included in the program are preset and calibration, voltage measurement, frequency measurement, comparison of waveshape to waveshape standard and high accuracy time-base measurements and comparisons. These operations reflect a behavioral analysis of maintenance usage of this test equipment in conjunction with electronic communications equipment. The appendix contains technical information for building a small signal generator for use with this program.

265. Zinser, O., *Imitation, Modeling, and Cross-Cultural Training*, AMRL Technical Report 66-88, July 1966. AD 642 427.

A study of the literature on imitation and modeling was conducted to aid in development of a modeling training technique to accelerate the acquisition of cross-cultural interaction skills. The modeling procedure is designed to provide exemplary behavior to the trainee via video tape recording. The literature review includes a summary of theoretical positions that have been formulated, a survey of research in terms of the variables that have been investigated, and a review of modeling techniques that have found application. A discussion devoted to implications for developing a cross-cultural training technique is also presented. The advantages and disadvantages of various procedures for constructing an effective modeling technique are examined. The literature reviewed indicated that a modeling training technique has to date not been used to aid in the acquisition of cross-cultural interaction skills. The report concludes with the recommendation that the effectiveness of such a training technique be evaluated.

ABSTRACTS FOR 1967

266. Askren, W. B. (Ed.), *Symposium on Reliability of Human Performance in Work*. AMRL-TR-67-88. May 1967. AD 659 140.

This report is a compilation of the papers presented during the symposium, "The Reliability of Human Performance In Work" at the 1966 Annual Convention of the American Psychological Association. Dr. Altman's paper is concerned with the classification and combination of human error data in psychologically meaningful ways. He examines alternative ways of classifying human error to facilitate integration of error data for reliability estimates that will be useful to the psychologist. Dr. Swain discusses some practical limitations in using the simple multiplicative model with a molecular definition of behavioral elements to estimate task reliability in man-machine systems. He describes advantages of estimating conditional probabilities of larger (molar) units of behavior when employing the probability tree technique in reliability analysis. Dr. Meister's paper addresses the importance of production worker error to system reliability, together with characteristics that differentiate production error from operating error. Factors that predispose to worker error are analyzed in the context of the production process as a man-machine system.

267. Basinger, J. D. and Holden, L. D., *Development of Measurement Techniques for Evaluation of a Visual Simulation System*. Technical Report AMRL-TR-67-90, June 1967. AD 820 280.

The purpose of this study was to develop evaluation techniques for visual simulation and to obtain an improved display for the SMK-23 Visual Simulator Attachment. In the past, evaluation techniques have been developed for television subsystems, but have not included the optical probe. This report documents techniques developed for the evaluation of the optical probe using the television camera as the measuring instrument. This permits the evaluation of the optical probe as it is actually used in the Visual Simulator. The evaluation includes resolution, depth of field, and flatness of field. To improve the picture quality of the SMK-23, different optical probes were evaluated and the sequential color television system was modified to 1029-line, high resolution monochrome television. In the original SMK-23, system performance is limited by the bead lens optical probe. This probe limits the resolution, depth of field, and flatness of field of the final display. The Librascope optical probe overcomes these limitations and is recommended to replace the bead. The conversion of the SMK-23 to monochrome television greatly improves the resolution capabilities of the system, and also eliminates the color misregistration that is inherent in the original system. By using both the monochrome system and Librascope optical probe, the light available to the pickup tube is greatly increased. This permits the use of a less sensitive and less expensive image orthicon pickup tube and improves signal-to-noise ratio.

268. Chiles, W. D., "Methodology in the Assessment of Complex Performance: Discussion and Conclusions," *Human Factors*, 9 (4), 385-392. 1967. Also identified as AMRL-TR-67-98.

This paper summarizes the discussion elicited by the preceding papers. Subsequent to the conference, the tape recordings of the discussion were perused and a series of statements were identified as representing possible points of agreement on the issues considered. These statements were evaluated by 15 people who participated in the conference on a semantic differential scale (agree vs disagree). The most important conclusions relate to the criterion problem, task taxonomies, the reliability of measures, and the role of face validity in the design of research apparatus.

269. Chiles, W. D., *Assessment of Complex Operator Performance*. Technical Report AMRL-TR-67-239, August 1967. AD 681 539.

The papers included in these proceedings provided the substance for the discussion of a variety of methodological problems encountered in carrying out research for the purpose of assessing the capabilities of the human operator to perform complex tasks. The discussion took place during a two-day conference held at the facilities of the Training Research Division at Wright-Patterson Air Force Base on 29 and 30 March 1966. Papers included in the proceedings are: "Methodology in the Assessment of Complex Performance: Introduction," "What does the Operator Do in Complex Systems," "The Use of Full Scale Mission Simulation for the Assessment of Complex Operator Performance Assessment Based on the Empirically Derived Task Taxonomy," "The Identification of Performance Dimensions Through Factor Analysis," "Methodology in the Use of Synthetic Tasks to Assess Complex Performance," and "Methodology in the Assessment of Complex Performance: Discussion and Conclusions."

270. Cotterman, T. E., and Wood, M. E., *Retention of Simulated Lunar Landing Mission Skills; A Test of Pilot Reliability*, Technical Report, AMRL 66-222, April 1967, AD 817 232.

Four crews of three pilots were tested on a simulated 7-day lunar landing mission at intervals of 4, 8, 9, and 13 weeks, after original training. The 6 weeks of training had culminated in real time performance of the missions but, for the skill retention test the missions were compressed into a single 13-hour workday by omitting less significant tasks and waiting periods. Following the test 1 or 3 days of additional training on selected mission phases was given all crews. The analysis of results focused attention on individual and crew performance at the end of training, in the skill retention test mission, and in the following retraining trials, as represented by 22 selected flight control parameters distributed over nine mission phases. Using novel analytic techniques the levels of performance observed were given as reliabilities, or probabilities of success. Also, for sensitivity to changes in capability, test and retraining performances were alternatively given as probabilities of success in meeting the level of performance estimated achievable by each individual in 95% of his performances at the end of training. The obtained probabilities are taken to indicate (1) lack of direct practice of critical tasks over 8 weeks or more in space missions will result in unacceptable skill deterioration unless suitable remedies are sought in design, and operational planning. (2) aerospace research pilots are capable of performing the type of mission used in this study, if extreme care is given to their training and individual performance reliability is demonstrated. The needs for further research on skill retention is indicated and the advantages of the analytic methodology are stated.

271. Eckstrand, G. A., Askren, W. B. and Snyder, M. T., *Human Resources Engineering: A New Challenge*. Human Factors, 9 (6) 517-520. 1967. Also identified as AMRL-TR-67-167 by Aerospace Medical Research Laboratories. AD 708 115.

The concept of human resources engineering is introduced, which is the process of using human skill resources as factors in design trade-off studies. The development of the military's response to human resources needs in systems in traced from the reacting phase, through the current predicting phase, to a possible future phase involving some degree of control. The implementation of the control phase will require a human resources engineering technology. The establishing of such a technology will require research in the areas of data structuring, methods for relating data to design and life cycle costing, and computerized banks of human resources data.

272. Elliott, T. K., *The Maintenance Task Simulator (MTS-2): A Device for Electronic Maintenance Research, Volume I: Application and Operation*. Technical Report AMRL-TR-67-140, Vol. I, October 1967. AD 664 085.

The MTS-2 was developed in response to a demand for a realistically complex, relatively low cost, reliable, substrate on which the tasks associated with electronic maintenance could be performed. It provides the capability for collection of performance data on such tasks as front panel check-out, between and within stage troubleshooting, alignment, and remove-replace operations, with a minimum of interference with task performance. A time based record of control manipulsations, component exchanges, and test point tests is automatically printed. In addition, the device provides a measure of capability for varying such equipment characteristics as front panel layout, type of controls and displays, type of internal circuitry, data flow configuration, etc. Physically, the MTS-2 is composed of six relay racks which contain or support 96 solid-state circuit modules of 20 types, 85 controls and displays of 15 types, and all response sensing and recording equipment.

273. Elliott, T. K., *The Maintenance Task Simulator (MTS-2): A Device for Electronic Maintenance Research*, Vol. II: *Maintenance Data.* Technical Report AMRL-TR-67-140, Vol. II. October 1967. AD 664 077.

This report contains schematics, theory of operations, parts location, and interconnection tables for the MTS-2 maintenance task simulator. The data includes front panel modules and circuit modules, but excludes commercial items incorporated intact in the device.

274. Elliott, T. K., *Development of Fully Proceduralized Troubleshooting Routines*. Technical Report AMRL-TR-67-152, November 1967. AD 664 076.

Several studies over the past decade have shown that proceduralized troubleshooting can produce acceptable or better performance of this complex maintenance task while permitting substantial reduction in the costly training typically associated with its accomplishement. The term "proceduralized troubleshooting" is usually applied when the decision about where in the system the technician is to check next, based on the results of previous checks, is made by a performance aid which directs his actions. This same performance aid, however, can also display expected normal readings and tolerance, test equipment and test selection parts identification, and much other necessary and/or useful guidance. The method described follows from experiences with and subsequent to development of a fully proceduralized within stage troubleshooting performance system for purposes of experimental evaluation. It is based upon the rationale of maximizing information gain per unit test or operation cost. Examples of troubleshooting procedures developed for use in the evaluation are presented and described.

275. Elliott, T. K., *The Effect of Electronic Aptitude on Performance of Proceduralized Troubleshooting Tasks*. AMRL Technical Report 67-154, November 1967. AD 664 889.

After twelve hours training, twenty subjects with no prior training in electronics solved complete electronic equipment maintenance problems on a realistic equipment simulator, the MTS-2. Subjects selected were from two electronic aptitude groups (AQE-E-1 45-60 and 80-95 percentiles). The problems were composed of equipment checkout, malfunctioning "black box" isolation (within stage troubleshooting), piece-part isolation (within stage troubleshooting), and repair tasks. In lieu of expensive conventional electronic training, subjects were aided in the performance of the above tasks by troubleshooting guides which, given the result of previous checks, told subjects where to check next. Results of the study showed that aptitude had no effect on performance time, or errors in repair. A small but significant difference was noted in the ability of the two groups to isolate defective "black boxes" and piece parts; high-aptitude subjects performed somewhat better on this dimension.

276. Folley, J. D., Jr. and Elliott, T. K., *A Field Survey of Electronic Maintenance Technical Data.* AMRL Technical Report 67-159, November 1967, AD 666 990.

A survey, using interview and observation, was made in five subject areas to determine current and anticipated problems associated with development and use of performance aids in the Air Force, and to identify implications of those problems for relevant research. The five areas surveyed are: job-task content and current performance aids for electronic technicians at typical Air Force sites, unique problems of performance aids in limited war operations, current requirements for optimum performance aids, and current and future developments in performance aids technology. Visits were made to 12 different Air Force bases, nine equipment development firms and laboratories, one commercial airline maintenance facility, one commercial communications firm, and conversations with ten researchers working in technical data and job performance. About 800 man-hours were spent in collecting information. The survey indicated that a wide range of maintenance concepts are found in the field (from complete modular replacement to replacement of piece parts such as resistors and capacitors); that limited war operations do not change the job-tasks and the performance aid requirements of the electronic technician; that a number of job performance aids systems based on advanced technology have been tested and found to be effective; but that advanced training and performance aids technologies have not been generally applied to operational situations although the vocabulary associated with these technologies is often used.

277. Gaudiosi, J. V., *Simultaneous 8-Channel Cathode Ray Tube Display System,* Technical Report AMRL-TR-67-13, December 1967. AD 664 552.

This report describes the technical features of an 8-channel Cathode Ray Tube Oscilloscope System. The primary proposed utilization of the system is for providing the capability of synthesizing a variety of displays as related to cockpit instrumentation for conducting research in the area of simulation and training. The primary features of this system are the following: 1. Individually, manual and remote voltage-controllable X and Y positioning is provided for each signal; 2. Individually, manual or remote voltage-controllable intensity is provided for each signal; 3. Overall manual X and Y positioning of the 8-signal group is provided; 4. X and Y positioning stability within ±1% for a duration of 8 hours after a 15-minute warmup period is provided; 5. X, Y, and Z channels are dc-coupled throughout; 6. X and Y deflection amplifiers provide nominal 300 V peak-to-peak push-pull output swings symmetrical about ground; 7. X and Y deflection amplifier frequency response is flat from dc to 100 KC within ±1 db at 85 volts peak-to-peak output and driving into a 500 pf load; 8. Remote (up to 20 feet) CRT driving capability is provided.

278. Girod, C. V., Jr. and Pourciau, L. L., *Study and Development of Television Projector Video Amplifier Techniques*, Technical Report AMRL-TR-67-61, July 1967. AD 660 912.

To determine the most suitable technique to provide a wideband (30-mc) high level (150 volts, peak-to-peak) video amplifier for use with experimental and developmental television projectors, various techniques for obtaining wideband amplification were investigated. The techniques investigated were: shunt, series and combination peaking, distributed amplification, negative feedback, and modulated ratio frequency carrier. The primary problem was that of providing wideband amplification and high output level to a load that consisted of a resistor in parallel with various unavoidable capacitances which result from stage output capacitance, stray and wiring capacitances, and the input capacitance of the driven device. The capacitance limits the bandwidth of the amplifier, inversely propotional to the resistor-capacitance product. The study resulted in the design and construction of a solid-state video amplifier, employing a combination of feedback and peaking techniques, which meets the required performance characteristics. The amplifier provides a bandwidth of 30 Hz, a gain of 300 and an output capability of 150 volts.

279. Gum, D. R., *Trends in Digital Flight Simulation for Training*, Technical Report AMRL-TR-67-50, May 1967. (AD 699 710).

This paper is concerned chiefly with the use of digital computers, mathematical modeling, and programming techniques for simulating aerospace vehicles for training purposes. The paper discusses past, present, and future trends in the use of computers and their associated equipment for training simulation. The rapid advances in the computer field over the past six years along with their impact on simulation and simulation research are discussed. The controversial areas of digital simulation program iteration rates and numerical integration are ingeminated. Arguments for the use of more sophisticated floating point processors for advanced aerospace vehicle simulations are presented. Finally, future developments and approaches to digital flight simulation are advanced.

280. Heinz, D. M., Hebert, H. J. and Sharp, W. N., *Development of Photoresistive Elements for an Analog Multiplier*. Technical Report AMRL-TR-67-168, December 1967. AD 671 980.

Cadmium sulfide layer photoresistive cells having improved properties and improved cell-to-cell uniformity have been developed for use in an analog multiplier. Each program objective--a temperature coefficient below 0.1 percent per C°, a voltage effect coefficient below 0.02 percent per volt, and a response time of less than 10 msec.--has been realized in an individual photocell but all of these characteristics have not been embodied in a single photocell. The fabrication techniques employed on this program, including vacuum deposition, heat treatment, electroding and encapsulation are described. Measurement techniques for evaluating temperature effect, voltage effect, response time, and long-term stability are presented.

281. Horton, J. A. and Bartucci, J. F., *Study and Development of a Simulation Infinite Depth of Field Optical Pickup*. Technical Report AMRL-TR-67-197, November 1967. AD 666 939.

Sufficient depth of field is an inherent problem in all conventional optical pickup designs. The solution in the past has been to operate at higher f-numbers and accept the increased object-lighting requirements. In Phase I of this program, several techniques were investigated that utilized the Schiempflug condition to increase the depth of the field without affecting the f-number of the pickup. Of these techniques one proving especially useful involved the tilting of the final imaging lens about its rear nodal point to compensate for the final image tilt. Theoretical analyses indicated that at f/6 a minimum altitude of approximately 23.6 mm (0.93 in.) can be reached with full image-tilt compensation. The final system produced during Phase II, possesses the following characteristics: f-number of six, effective focal length of 15.1 mm (0.6 in.), 80-deg circular field of view, 25.4 mm (1-in.) diameter output format, and resolution of more than 60 lines per millimeter on axis.

282. King, P. H., "Cultural Training for Air Force Advisors," USAF *Instructors Journal*, Vol. V, No. 1, Summer 1967.

This article stresses the need to recognize inadequate preparation for interacting with people in other societies. The research results using self-confrontation techniques are described along with results obtained in acquisition and retention of knowledges and skills. The self-confrontation training technique involves simulation and the feedback via video tape of a complete visual and audio record of individual and group performance in given role-playing situations.

283. Knoop, Patricia A., *The Application of Schur's Algorithm to the Derivation of Optimal Numerical Integration Technique for Digital Flight Simulation*, Technical Report AMRL-TR-67-3, March 1967. AD 654 320.

This report describes the derivation and application of a computer-oriented technique for synthesizing numerical integration methods which are optimal on the basis of stability alone. The local growth of propagated error during a numerical integration and its effect on stability is explored. Also, a unique approach for deriving both classical and non-classical integration methods is presented. Schur's algorithm is used to formulate the search for an optimal kth-order integration method as a non-linear programming problem suitable for computer implementation. First and second order methods which are optimal on the basis of stability alone are derived. Finally, the technique developed in this study is used to derive the "stability ranges" for several well known integration formulae for purposes of evaluating their adequacy for a given simulation problem.

284. Knoop, Patricia, A., "Automated Aids for Flight Simulator Instructors," *USAF Instructors Journal*, Spring 1967.

Recent developments in computers and programming techniques have produced new potentials for the use of flight simulators in training. But because these potentials yet have not been tapped, simulator instructors are unnecessarily overloaded with time-consuming pilot performance monitoring and recording tasks. The use of digital computers for simulation permits a remedy to this problem through the use of automated instructor aids. Most important of these aids are objective automatic performance evaluation techniques which would provide the instructor concise, easily interpreted indices of pilot performance. These indicies would be useful in efficiently analyzing and correcting individual pilot deficiencies as well as in predicting accurately when the man in training is prepared for the mission.

285. McNeal, R. N., *Development of an Input/Output Technique for Integrated Circuit Simulation Computers*, Technical Report AMRL TR-67-74, July 1967. AD 660 847.

The basic system requirements and the overall system design technique for an input/output system are described based on an input/output technique developed to interface between integrated circuit computers and simulation systems. Four general types of signals are processed by this input/output system: discrete inputs, discrete outputs, analog inputs, and analog outputs. This study has determined that integrated circuits are readily adaptable to performing the digital functions in the input/output system, but the analog signal conversion requirements of these systems are not within present linear integrated circuit capabilities. It is anticipated that the linear integrated circuit development will have progressed to the point of making integrated circuit converters feasible within the next year.

286. Meyer, D. E., Flexman, R. E., Van Gundy, E. A., Killian, D. C. and Lanahan, C. J., *A Study of Simulator Capabilities in an Operational Training Program*. Technical Report AMRL-TR-67-14, May 1967. AD 656 308.

The experiment was conducted to determine the effects of simulator training to criterion proficiency upon time required in the aircraft. Data were also collected on proficiency levels attained, self-confidence levels, individual estimates of capability and sources from which that capability was derived. Subjects for the experiment were 48 airline captains transitioning into the DC-8 aircraft. The subjects were equally assigned to experimental and control treatment groups. Subjects in the experimental group were trained in the DC-8 simulator for as much time as required to satisfy their instructors that they could perform the required maneuvers in the simulator at the same level of proficiency required to pass the final qualifications check in the aircraft. The control group was trained using the standard curricula which required a fixed time in the simulator. Data obtained from student reactions to questionnaire items are interpreted to indicate that: (1) simulators can be used to further reduce requirements for training time in aircraft; and (2) simulators can be used to evaluate performance that is indicative of performance in the aircraft.

287. Nigro, B. J., *Study of Numerical Integration Techniques for Real-Time Digital Flight Simulation*, Technical Report AMRL-TR-67-4, March 1967. AD 654 307.

A comprehensive and rigorous mathematical analysis of numerical integration techniques for real-time digital flight simulation is presented. Accuracy and efficiency of methods as well as stability of numerical solutions are examined in detail. These investigations allow the subject of "best" integration methods and their derivation to be pursued. "Best" methods based on accuracy/efficiency and on stability are developed; in addition, the Stability Chart and Z-Transform approaches are examined. This study allows certain evaluational techniques to be derived. Notable among these are a technique for evaluating any integration method and a technique for deriving a "best" method for a given digital flight simulation problem. A demonstration section is included wherein the utility of these techniques is established.

288. Pieper, W. J. and Folley, J. D., Jr., *Effect of Ambiguous Test Results on Troubleshooting Performance*. AMRL Technical Report 67-160, November 1967. AD 664 891.

Forty-eight high school boys were divided into eight groups of six each. Four of the groups represented "medium" electronic aptitude (40 to 65 percentile range on the Airman Qualifying Exam). The other groups contained subjects with "high", (75 to 99 percentile) electronic aptitude. Each subject received 11 hours of training and practice in isolating malfunctioning components in data-flow diagrams using the half-split strategy. During testing each subject group worked 24 paper and pencil between-stage troubleshooting problems, one set of 6 at each of four levels of ambiguity (0%, 10%, 20% and 40%). Ambiguous test results were simulated by the statement "unknown" as opposed to "good" or "bad" for unambiguous test results. The performance measures used were: (1) isolation time, (2) number of isolation tests, and (3) identification errors. Subject aptitude had the greatest effect on speed (isolation time) and accuracy of identifying the guilty component (identification errors). On the other hand aptitude had no effect on the application of the troubleshooting strategy since both medium and high aptitude subjects used the same number of tests in solving the problems. Ambiguity of test results affected speed, accuracy, and application of the strategy. The greater the percentage of ambiguous test results, the more time required, the less accuracy attained, and the greater the number of checks used in solving the problems.

289. Reed, L. E., *Advances in the Use of Computers for Handling Human Factors Task Data*, Technical Report AMRL-TR-67-16. April 1967. AD 656 701.

The relative simplicity of early systems was such that human requirements (skills) were easily interchanged within and between systems. Current complex aerosystems are accompanied by an increased need for closer consideration of the human component. The amounts of information generated and the compressed developmental schedules have led the specialist to rely heavily on his own expertise when existing data are not known to exist or are inaccessible. As such, the input to early identification of requirements and the integration of these requirements into training programs has suffered. In 1963, the Aerospace Medical Research Laboratories and the National Aeronautics and Space Administration, initiated a joint research program to explore, and where possible, develop techniques for handling and processing human factors task data (task analysis/maintenance analysis). It is anticipated that the techniques will assist the human factors specialist in industry and the Government to make better use of available data for making decisions about the training of system maintenance and operator personnel. The techniques will also be useful in carrying out a variety of other functions related to the human side of aerospace system development.

290. Reed, L. E. and Wise, F. H., "Report on Automated Human Factors Task Data Handling Research," Human Factors, 9 (2), pp 181-186, 1967. Also identified as AMRL-TR-66-117 by Aerospace Medical Research Laboratories.

The relative simplicity of early systems was such that hardware components and the accompanying human requirements (skills) were easily interchanged within and between systems. Current complex systems are accompanied by an increased need for closer consideration of the human component. The volumes of information generated and the compressed developmental schedules have led to: (1) decreased effectiveness of data on system design and development, (2) increased reliance on expertise when existing data are not known to exist or are inaccessible, (3) generation of inadvertent duplication of research effort, and (4) scattering of costly information. In 1963, the Aerospace Medical Research Laboratories and the National Aeronautics and Space Administration, initiated a joint research effort to explore and, where possible, develop techniques for efficient handling and processing of human factors task data generated in support of the Personnel Subsystem program. These techniques are being developed within the context of an overall data handling system concept which would operate in an Air Force/NASA/contractor environment.

291. Shim, I. H., *System Design Study for Radar Land Mass Transparency Preparation*, Technical Report AMRL-TR-67-56, September 1967. AD 664 357.

The purpose of the program was to conduct a study for the design of a land mass transparency recording system using laser techniques. The study considered the optics necessary for focusing and modulating the laser beam, the electronics necessary to decode the tape reader's input, the electronics and mechanics of the scan generation system, film stability, and human factors aspects of film handling. The rotating drum configuration was selected as the most suitable approach. The analysis delved into focusing variations due to fabrication tolerances, the control of jitter arising from bearing and motor disturbances. The analysis shows that 100 lp per millimeter resolution can be achieved over the entire transparency and line-to-line jitter can be held to less than one-tenth of a spot diameter.

292. Smith, E. A., *Comparison of Behind-the-Lens Meter Readings and Incident Light Meter Readings in Producing 35 mon Color Slides for Technical Training Classes*, AMRL Technical Report 66-112, September 1967. AD 665 467.

The study reported here relates to the possibility that behind-the-lens meter in 35mm cameras might facilitate the taking of colored slides by simplifying the technique for determining exposure. A series of test slides, representing various types of slides used in technical training classes, briefings, and presentation was made and evaluated. These pictures included indoor shots of charts, graphs, newspaper clippings, colored posters, and live subjects. The data indicate that exposure estimates obtained from behind-the-lens meters vary significantly from those obtained from incident light meters. In approximately one-half of the 48 cases compared, the difference was at least one f-stop. The difference was not systematic but varied in both degree and direction. When viewing the slides in pairs, both a group of 37 university students and a group of 17 adult members of a photography club exhibited a strong tendency to find the slide based on the incident light meter to be more acceptable than the slide based on the behind-the-lens meter.

293. Snyder, M. T., "The American Military Adviser Overseas: His Roles and Responsibilities," paper presented at meeting of American Psychological Association in New York, September 1966. *American Psychologist*, Vol. 21, 1967.

Many of the missions being carried out by our military advisers today are dependent for their success upon effective communications and interactions between our personnel and the personnel from other countries whose culture differs from our own. These missions place considerable emphasis on training and advising of foreign counterparts who differ greatly from the American military man in terms of cultural background. This paper presents some of the various roles assumed by military personnel in foreign countries and examines some of the cross-cultural responsibilities of the practicing military advisers to himself, to team-mates, to counterparts and to host populations. These responsibilities are discussed under five areas: Sharing, Personality, Communications, Attitudes, and Learning.

294. Soxman, E. J., *Development of Thin Film Electroluminescent Display Techniques*, Technical Report AMRL-TR-67-1, April 1967. AD 655 903.

An electroluminescent display panel of the cross-grid matrix-type was fabricated on a 10 3/4 x 10 3/4 inch glass substrate using improved vacum deposition procedures and a high brightness manganese-doped ZnS phosphor. This panel contained 256 x 256 active elements within an area of approximately 7 x 7 inches. Linear resolution was 36 elements per inch with a cross-conductor width of 0.020 inch and a separation of 0.007 inch. The display panel was successfully used as a viewing screen for rear-projected images. The brightness-voltage relationship of the thin film phosphor was such that a cross-suppression ratio in excess of 10,000 to 1 was achieved with an excited element brightness of 100 ft-L. Performance measurements indicated that the optimum drive frequency was about 15 kHz. For pulsed operation, a burst frequency of 37.5 Hz, a carrier frequency of 15 kHz, and a duty cycle of 0.25 percent gave an average brightness of a few foot-Lamberts. Useful operating lifetime of several hundred hours under the above conditions was indicated by preliminary data. The varation in brightness uniformity over a group of cells near the center of the panel was less than 7 percent at an average brightness level of 16 ft-L. A brightness reduction of about 12 percent was observed at a single cell when the contacting configuration was varied on the stannic oxide electrode.

295. Stoner, L. D. and Keates, D., *Simulation Image Generation: Study of Transparency and Stylized Image Techniques; Virtual Image Display*. Technical Report AMRL-TR-66-18, Vol. II, April 1967. AD 818 940.

Simulation devices for high-speed low-level flight, approach, and landing are considered deficient in one or more of these areas: (1) depth of field, (2) resolution, (3) perspective, and (4) shading. Phase II of this study is an investigation of these problems as they relate to flying spot scanner (FSS) and stylized visual image generation. Goodyear Aerospace also designed, fabricated, and tested a lightweight laboratory infinity-optics display. Most FSS image generators and display systems employ direct real-time TV synchronized pickup and standard TV displays. For low-level aircraft applications, the field of view is oriented about the longitudinal axis. This orientation requires creation of maximum scene perspective from plan-view transparency data storage. Current techniques employ specially shaped pickup rasters to generate perspective of the 2D ground plane. The rasters generally are quadrilaterals but frequently are nearly triangular trapezoids with apex in the near-field area approaching the nadir. Standard imaging optics causes serious losses of resolution in the near field (poor depth of field). Especially designed optics systems will significantly improve relative resolution with some required perspective transformations. The GAC study extended the definitions of FSS systems to include scanning pickups, suitable light sources, conventional pictorial transparencies, and the coupling optics subsystem. Such FSS systems appear to have much greater long-range potential but currently suffer lack of partial perspective-creation optics and a great deal less flexibility and quality for shaped pickup raster means of completing perspective. Stylized image-generation systems currently employ special-purpose computers for executive functions and for video formation of the scene presented on a standard TV display. A current space application provides three-window capability of projecting, in color, ground and sky planes with an additional rendezvous-plane provision. Three dimensional convex rectilinear object capability is being added. Existing stylized concepts operate with primitive language limited in capability of describing a visual scene. A more sophisticated language will permit easier execution of present imagery or will permit advancement in scene complexity in terms of form, number, and variance of objects displayed. The human viewer's ability to consume visual data and his sensitivities to data presentation offer some improvement possibilities. Generally, equipment concepts and hardware for permitting fast selective storage and recall and random or quasirandom data format assembly are currently unsatisfactory. A wide need exists for various video-tape storage devices, capable of operating in real-time with ordinary and high resolution TV equipment.

296. Tulley, A. T. and Meyer, G. R., *Implementation of Computer Software Techniques to Human Factors Task Data Handling Problems*, Technical Report AMRL-TR-67-127, September 1967. AD 663 209.

Research leading to the implementation of computer software techniques for handling human factors task data generated in support of aerospace system development programs is discussed. Techniques being explored in this research program are based on the assumption that a user-oriented computerized data system will help draw human factors specialists closer to needed data. The application of such a system will reduce the problem of data accessibiltiy and allow more effective use of data in the system engineering process. Preliminary research leading to proposed data handling techniques is discussed. A computerized data handling system to store, retrieve, and process human factors task data is initially implemented through a pilot study. A discussion of the pilot study specification is followed by a presentation of the design specification for a computerized experimental system. The experimental system, referred to as the pilot study experimental system, provides the primary means for demonstrating and evaluating the research results against the original research goals. Computer software descriptions are presented for implementing the pilot study experimental system in a user oriented environment in terms of information needs of human factors specialists.

ABSTRACTS FOR 1968

297. Cotterman, T. E. and Knoop, Patricia A., *Tables of Limiting t Values for Probabilities to the Nearest .001 (n=2-16)*, Technical Report AMRL-TR-67-161, May 1968. AD 673 347.

Tables of *t* to the nearest .00001 for probabilities within the range of .000 to .500, by increments of .001, are presented for samples of 2 through 16. The *t* values given are the limiting or boundary values having the indicated probability, rather than the closest approximation, thus making interpolation unnecessary in typical use. The tables are intended primarily as an aid in implementing a purposive probabilistic approach to psychological measurement in which the *t* distribution (or some other appropriate model) is used as a reference in deriving probabilistic behavioral measures. Secondarily, they also may be used to achieve greater precision in specifying the critical *t* for conventional tests of significance. The manner of use is briefly explained, and the way in which they were constructed is described. The FORTRAN computer program used in constructing them is included.

298. Elliott, T. K. and Joyce, R. P., *An Experimental Comparison of Procedural and Conventional Electronic Troubleshooting*, Technical Report AFHRL-TR-68-1. November 1968. AD 681 510.

Two groups of subjects solved the same set of 13 troubleshooting and repair problems in seven solid-state circuit modules which contained up to five stages each. Both groups used the same hand tools and test equipment. One group was composed of 41 Air Force 5- and 7-level technicians who normally maintain such equipment as part of their jobs. The technicians used the same troubleshooting techniques they ordinarily used on their jobs, and they were provided with a conventional technical order-like performance aid to support the task. The other group was composed of 20 high school students with no prior training or experience in electronics. Their training for this study consisted of a special 12-hour course (compared to several months for the technicians) and they used a specially developed performance aid which told them which check to make, based on the outcome of previous checks. In terms of the speed with which they were able to effect repairs on the modules, there were no substantial differences between the two groups. But the difference in training time and, therefore, cost of training between the two groups is so great as to suggest the possibility that job-relevant training and proceduralization of the task can introduce substantial savings, even after the cost of developing the special performance aids required by proceduralized troubleshooting is subtracted. The findings of the series of six studies of which this study was one are also summarized.

299. Foley, W. L., *Application of Laser and Rotating Mirror Systems to Generation of High Resolution Displays*, Technical Report AMRL-TR-68-28. December 1968. AD 691 013.

Conventional rotating mirror systems are analyzed for the ultimate potential in display fidelity as expressed in terms of the maximum number of spot diameters across the field. Consideration is given to systems where an axis focusing of the laser beam is employed and maximum resolution figures are obtained as function of scanner geometry and maximum rotational rates. Electronic drive systems are discussed, wherein both conventional and distributed amplification techniques are investigated for compatibility with solid state video modulators. The modulator is matched to the design configuration for each of the amplification techniques so as to optimize the bandwidth, drive voltage, and power requirements for the system.

300. Holden, L. D., *Development of Visual Simulation Modification for Field Evaluation*, Technical Report AFHRL-TR-68-3, October 1968. AD 681 175.

The purposes of this effort was to modify an SMK-23 Visual Simulator Attachment for use in determining the training value of various configurations of visual simulation systems. This report documents the required modifications to the SMK-23 television system to convert it from projected field sequential color operation to projected high resolution monochrome. Also documented is the replacement of the projection system with a high resolution monochrome lens-monitor system. A comparative evaluation of the original SMK-23 television system and the two modified display systems is presented. The lens-monitor type display is a vast improvement over the other systems. This display provides the advantages of high resolution, more contrast and brightness, a virtual image, as well as more reliability and lower cost. Finally, an improved SMK-23 model lighting system is described which enhances the television display contrast and yet uses only 20% of the original light power.

301. Kincaid, J. P., Investigating the Chemistry of Learning. *USAF Instructors Journal*. Summer 1968, AMRL-TR-68-47. AD 728 886.

This report discusses the current state of our knowledge about the chemistry of learning and possible future applications of this knowledge to classrooms situations. The role of stimulants, chemical transfer of learning by injecting "trained" RNA (ribonucleic acid) into naive subjects, and some of the basic mechanisms of memory are very briefly discussed. The report concludes that large-scale uses of chemical aids to learning are not currently feasible but that future research might result in some very valuable developments.

302. Knoop, Patricia A., *Development and Evaluation of a Digital Computer Program for Automatic Human Performance Monitoring in Flight Simulator Training*, Technical Report AMRL-TR-67-97, August 1968. AD 675 542.

A digital computer program for automatic human performance monitoring in flight simulator training was designed, implemented, and evaluated. The program is general purpose in design and consists of two segments: (1) the Input segment, permitting performance measures and criteria to be defined and updated on-line by the instructor and allowing the instructor to request integrated performance information to be displayed or recorded; and (2) the Monitoring segment, operating on defined criteria to monitor and evaluate performance. The program was implemented on a Raytheon 440 computer and operated in real-time with an orbital reentry vehicle simulation. Evaluations were made of the program's utility in monitoring and scoring tasks involving manual attainment of retro-attitude and rate control, and procedural tasks for reentry operations. The monitoring program was also applied to a representative tracking task to compare its efficiency with that of a special purpose monitoring approach. The research allows the following conclusion and recommendations to be made: (1) a general purpose program capable of a variety of performance monitoring and evaluating applications in a simulator training is feasible and directly applicable to increasing the effective use of simulators; (2) with minor revisions to the prototype system, the monitoring program will operate within the spare time and memory of current flight simulators; (3) it is not justifiable to attempt to gain program efficiency at the expense of operational flexibility; and (4) a version of the present program can now be implemented in an operational simulator training system for field evaluation.

303. Meister, D., Sullivan, D. J. and Askren, W. B., *The Impact of Manpower Requirements and Personnel Resources Data on System Design*, Technical Report AMRL-TR-68-44, September 1968. AD 678 864.

The major purpose of this study was to determine the effect on system design of using manpower and personnel resources data as design requirements. Secondary objectives were to determine under what conditions and in what form these data should be used to have maximum effect on design. Equipment, manpower data (e.g., quantities and skill levels), and personnel resources data (PRD) inputs (e.g., task information) which were produced during the development of the Titan III propellant transfer and pressurization subsystem were adapted and presented incrementally to six design engineers to simulate the Air Force phase 1A/1B development of that subsystem. Subjects were required to create schematics, equipment descriptions and drawings, control panel layouts, operating procedures and bills of material. Cost effectiveness measures including equipment cost, equipment reliability, human reliability, system safety and design adequacy were applied to the data. It was found that manpower requirements and PRD inputs do influence the equipment configuration, but in this study only moderately, because the equipment design proceeded so rapidly that incremental PRD inputs inevitably lagged the design. Engineers were responsive only to inputs which are framed as design requirements and which were interpreted in design-relevant terms. Confirming the result of previous studies, engineers were found to be generally unaware of or indifferent to personnel considerations. Different engineers interpreted the same design requirements and assigned priority to design criteria differently. The engineers relied heavily on experience and stereotyped solutions for design answers. The results of the study indicated that, if manpower and personnel resources data are to be incorporated into design, it is necessary to supply these inputs to the engineer as design requirements in his initial statement of work. Consequently, fundamental manpower and personnel analyses must be performed prior to the issuance of a Request for Proposal (RFP) and not delegated to the development contractor. The contractor must be required to design to a detailed manning structure which is specified in his statement of work. Further recommendations are supplied which suggest ways in which Air Force management of the personnel subsystem program should be revised.

304. Morgan, Ross L., "Education and Training Innovations in the Air Force", *USAF Instructors Journal,* Winter 1967-68, pp. 30-35.

The status of Educational and Training Innovations in the Air Force is summarized. The summary covers the management environment, general procedures for planning training, some educational and training innovations being used in the Air Force, and innovations being developed. The current healthy management environment and its vital importance are described. Innovations in the planning of training include the systematic and timely planning of training programs as an intergal portion of new weapons systems, the systems approach to training, and the development of job performance aids as a substitute for some technical training. The use of programed instruction is outline. Various uses of computers in educational and training systems are indicated. The discussion of innovations being developed includes computer-assisted instruction in relatively unconstrained English, the use of video-tape recordings of role-playing sessions to teach Air Force personnel the specific cultural behaviors they need to interact effectively with individuals from other cultures, the use of video-recordings in pilot training, and automated index of readibility, the use of microfilm training materials, and improved techniques for proficiency measurement. A special plea is made to evaluate all innovations.

305. Neese, J. A., *Description of Audio/Video Recording Equipment and Method of Installation for Pilot Training*, Technical Report AMRL-TR-68-73, October 1968. AD 683 022.

This report presents a detailed description of the Audio/Video Recorder System (AVRS) prototype designed by Conductron-Missouri. The purpose of this system is to permit an assessment of the feasibility and effectiveness of an in-flight audio/video recording capability in improving the instruction of Air Force pilot trainees. Construction and installation drawings are presented and discussed, tentative operating instructions are provided, and the maintenance and spare parts implications of the specific system design are detailed.

306. Nigro, B. J., Woodward, R. A. and Brucks, C. R., *A Digital Computer Program for Deriving Optimum Numerical Integration Techniques for Real-Time Flight Simulation*, Technical Report AMRL-TR-68-4, May 1968. AD 673 372.

An extension of a previous comprehensive and rigorous mathematical analysis of numerical integration techniques for real-time digital flight simulation is presented. This study has resulted in the creation of a FORTRAN computer program (The Simulation Analyzer Program) which can derive an optimum numerical integration method to solve the differential system associated with a simulation problem and satisfy all requirements (accuracy, speed, etc.) specified by the user. The Simulation Analyzer Program may also be used to evaluate user-supplied numerical integration methods for a given simulation problem. In the derivation of optimum methods as well as in the evaluation of user-supplied methods, the program considers consistency requirements, stability, truncation error, round-off-error, propagated error, and required computing time. This report includes a description of a family of three-step numerical integration methods which have arbitrarily large stability intervals and arbitrarily small truncation errors. Also included is a derivation of an exact expression for the propagated error produced in the numerical solution of a differential equation and a closed-form expression for percentage of error in the numerical solution. These derivations represent important advances in the state-of-the-art of numerical analysis.

307. Oller, R. G., *Human Factors Data Thesaurus (An Application to Task Data)*. Technical Report AMRL-TR-67-211, March 1968. AD 670 578.

This report describes how vocabulary and thesaurus techniques can be applied to a user-oriented computerized data handling system. These regulating devices help to reduce the problem data accessibility and allow more effective use of data in the system engineering process. An analysis is presented of the specialized problems associated with the development of vocabularies and rules for regulating their usage. The content of the report consists of glossaries of action verbs and nouns accompanied by appropriate rules of usage and cross-reference indexes of acceptable terms and their synonyms. All of the terms contained in the vocabularies are clearly defined and are mutually exclusive. Care was exercised to avoid selecting terms that had restricted usage, so they would be useful in a wide range of aerospace systems. The significance of the action verb listing is enhanced because verbs are basic to the precise expression of actions. Consistency in meaning of terms and rules governing their usage will reduce confusion when indexing data and help maintain the users confidence in the data retrieved. The vocabularies and rules for usage should, with modifications, be applicable to any data base containing aerospace factors data. Only limited additions should be required to the verb glossary to express any human actions associated with aerospace systems.

308. Pieper, W. J., Folley, J. D., Jr., Chenzoff, A. P. and Valverde, H. H., *Learner-Centered Instruction (LCI): Volume III--Plan of Instruction*, Technical Report AMRL-TR-68-116, October 1968. AD 691 462.

A Plan of Instruction (POI) is presented for an experimental course to train flight line Weapon Control System Technicians for the F-111A Aircraft (AFSC 322X1R). The POI is based upon the job behavioral description of this technician's job, prepared earlier. The two basic decisions establishing the character of the POI are (1) the overall objective of the course is to produce graduates who are capable of performing at the 5 level of skill with virtually no on-the-job training, and (2) the mode of instruction is to be Learner-Centered. The POI, therefore, emphasizes development of behavior patterns required by the technician on the job, and calls for self-instructional materials that the student uses at his own pace. The instructor concentrates on assisting the individual student when he needs help. The 15 week course is divided into seven major blocks. Each block is divided into units and lessons, with learning objectives stated for each.

309. Pieper, W. J., Folley, J. D., Jr. and Valverde, H. H., *Learner-Centered Instruction (LCI): Volume II--Job Behavioral Description for AFSC 322X1R.* Technical Report AMRL-TR-68-51, August 1968. AD 678 037.

This report describes the approach taken in the development of a job-behavioral description for the Learner-Centered Instruction (LCI), Weapon Control Systems Mechanic/Technician, Air Force Specialty Code (AFSC) 322X1R course to be conducted at Lowry AFB, Colorado. The behavioral description will serve as a basis for the preparation of Statements of Learning Objectives (SOLOS) and a performance criterion test in the development of the LCI course. The term LCI, as used in this advanced development program, refers to a course based upon a systems approach to training. The course is a job-oriented electronics course for training airmen to perform flight-line maintenance tasks on weapon control systems.

310. Purifoy, G. R., Jr., *Instructional Methodology and Experimental Design for Evaluating Audio/Video Support to Undergraduate Pilot Training*. Technical Report AFHRL-TR-68-5. October 1968. AD 680 408.

This report presents a detailed description of the methods by which airborne video recording will be utilized in the training of Air Force pilots, and presents plans for an assessment of its effectiveness. Audio/video equipment configurations and limitation are discussed as they apply to training operations in the T-37 and T-38 aircraft, and training methodology is described which has been formulated to permit the integration of video recording and teaching techniques into the Air Force Undergraduate Pilot Training program. Plans for an eight-month experimental evaluation of the effects of these techniques are detailed, including schedules, operating practices, student selection procedures, instructor training plans, data gathering processes and materials, and analysis guidelines.

311. Reardon, Sue E., *Computerized Human Factors Task Data Handling Techniques: User's and Controller's Operating Guides*. Technical Report, AMRL-TR-67-226. March 1968. AD 671 531.

Instructions are presented for the operation of an experimental computerized data handling system. The instructions were developed as part of the overall research into a user-oriented computerized system to store, retrieve, and process human factors task data. These instructions are intended as a model for future operating guides.

312. Ruhsam, W. M. and Kiowski, J. W., *Digital and Hybrid Simulation of an Orbital and Reentry Vehicle*, Technical Report AMRL-TR-67-139, May 1968. AD 673 517.

This report documents research on techniques and components that may be used to efficiently simulate an orbital and reentry vehicle with a digital or a hybrid computer system. A mathematical model based on a Gemini-type spacecraft is defined. The spacecraft model was simulated with three separate programs: (1) A digital program running at a single iteration rate for all parts of the simulation, (2) A digital program that operates with four concurrent iteration rates. Each iteration rate is associated with a grouping of the functions of the spacecraft model having similar frequencies. The higher frequency groups operate with the faster iteration rates. (3) A hybrid program that simulated the spacecraft with digital and analog equipment. Four photoresistive 8 common product multipliers were constructed to increase the computation capabilities of analog equipment. A study of techniques of function generation and program debugging is presented. The question of floating point versus fixed point programming for simulation is discussed.

313. Saund, D., "On the Limitations of Systems Analysis for Counterinsurgency Programs." *Air University Review*, Vol. XIX, No. 4, pp 43-51, May-June 1968. Also identified as AMRL-TR-68-109.

The limitations of system analysis for guiding counterinsurgency (COIN) efforts are examined and the findings are that system analysis does not show promise when compared to culturally acceptable solutions based on social science methods and concrete data from real situations. System analysis techniques have limitations for COIN efforts because (1) they require one to make assumptions a priori about the problem, (2) they cannot handle the kinds of variables that must be taken into account when planning COIN programs, and (3) they carry a real danger that unless those who use the results are well aware of the limitations, an apparently convincing case can be made for an erroneous solution.

314. Shim, I. H., Wigby, J. I. and Mletzko, A. E., *Design Study for Radar Land Mass Simulation System*, Technical Report AMRL-TR-68-8, May 1968. AD 673 908.

A design study and investigation to determine the requirements for the mechanical and electrical components of a Radar Land Mass Transparency System has been performed. The technique consists of moving a laser beam across a 122-cm square transparency to simulate the side-looking radar system of an aircraft. The most promising system of those considered from accuracy, complexity and cost considerations is shown to be a horizontally driven transparency with a vertically driven flying spot scanner. The spot, in its vertical heading, scans out a strip 5 cm wide. Spot size can be kept to 2.5 microns over the 5 cm scan length at any location on the transparency. Smoothness of motion to simulate an aircraft is achieved through a feedback control system designed to move at constant velocity. An overriding position loop will correct for any accumulated errors which could result from environmental or load condition changes. A position accuracy of ±0.00127 cm over the entire transparency is shown to be quite feasible. In addition, the speed range from low flying aircraft to satellites of approximately 100:1 is also shown to be feasible using the same system. Mechanical and electrical components chosen for performance calculations and tolerance determinations are off-the-shelf. These parts are easier to acquire and lower in cost than equivalent custom made components.

315. Smith, E. A., "Locally Produced Films," *USAF Instructors Journal*, Fall 1968.

Within the Air Force, there are numerous situations where specialized materials are taught only at one base for a short time, or on a specific device. Locally prepared 8 mm movies and 35 mm slide presentations, with or without accompanying lecturers should merit consideration in such situations. Films may be used where demonstration would be difficult because of the size and weight of equipment, availability of equipment, safety hazards, etc. Filmed materials also may be used as a preview or review of demonstrations and practical experience.

316. Snyder, M. T. and Askren, W. B., *Techniques for Developing Systems to Fit Manpower Resources*. Technical Report AFHRL-TR-68-12, October 1968. Also in the *Proceedings of the 14th Annual Army Human Factors Research and Development Conference*, U.S. Army Tank-Automotive Command, Warren, Michigan. AD 681 137.

This report discusses four related processes for developing systems within manning and skills constraints. The point is made that the services are beginning to feel the need to exert some measure of control over system design where human resources are involved. The report covers: (1) research to prove that certain human resources data, such as manning and skills data, when used as design constraints along with other constraints does affect system design; (2) techniques by which to match or balance through tradeoff practices the hardware, the human and other system support or logistic functions in order to get a best mix depending on the real world operational goals; (3) a new specification by which personnel requirements are stated in terms of system requirements, for integrating more fully the human requirements with the system engineering processes; (4) a newly developed computer based data handling system for human resources data in the conception, development, test and operation of systems. The new data system is also an integrator of human and hardware data within and across systems, and a mechanism for comparing field performance data with early design data.

317. Spencer, G. R., *Research and Development of High-Brightness Projection Kinescopes*, Technical Report AFHRL-TR-68-6, August 1968. AD 689 749.

In a preliminary Phase of study and experimentation, a number of luminescent materials were investigated to provide a basis of selection of a phosphor for subsequent application in a high-brightness projection cathode-ray tube. Utilizing the principle of forced-cooling of the phosphor substrate to limit the thermal contribution to brightness saturation, a projection tube was developed having an angled neck, an ion-trap tetrode gun, and a clear glass optional window situated parallel to a liquid-cooled metal base-plate on which the phosphor screen was deposited. Three models of this tube were constructed. Measurements showed the tube capable of providing an acceptable quality projection television display of 9 ft Lambets brightness in a 3' x 4' image, using an f/1.2 lens and viewing screen having a gain of 2. Tube life was found to be in excess of 500 hours of operation with continuous, intense, full-raster bombardment, resulting in less than 50% reduction in luminous efficiency.

318. Tulley, A. T., Meyer, G. R., Oller, R. G., Mitchell, P. J., Reardon, S. E. and Reed, L. E., *Development and Application of Computer Software Techniques to Human Factors Task Data Handling Problems*. Technical Report AFHRL-TR-68-13. November 1968. AD 682 362.

Research leading to the application and implementation of techniques for computer handling of human factors task data generated in support of aerospace system development programs is discussed. The technique development is based on the assumption that a user-oriented computerized data handling system will help draw human factors specialists closer to needed data. The application of these techniques should reduce the problem of data accessibility and allow more effective use of data in the system design and development process. A computerized data handling system to store, selectively retrieve, and process human factors data in a user-oriented environment was implemented through a Pilot Study Experimental System (PSES). This experimental system provided the primary means for evaluating the research results. This report discusses the development process of the PSES, the computer software used by the PSES, data classification techniques, and vocabulary controls. Consideration is also given to the feasibility of providing (1) analytic and simulation tools in a user-oriented environment, (2) current awareness notification of data entries, and (3) an advanced and sophisticated classification scheme for identifying functional relationships.

319. Valverde, H. H., *Effect of Confirmation Peeking and Response Mode on Programmed Instruction*. Technical Report AMRL-TR-67-225, December 1968. AD 686 422.

An experiment was conducted to determine the effect of peeking on programmed instruction. The study tested the following hypotheses: (1) the requirement for overt responses does not increase learning in programmed instruction, (2) devices or formats to preclude confirmation peeking do not increase the effectiveness of programmed instruction, and (3) time can be saved by eliminating the requirement for overt responses. Two groups of 39 subjects each were used. The subjects were commissioned officer Air Force pilot trainees and Air Force Reserve Officer Training Corps (AFROTC), junior and senior college students matched on the basis of scores obtained on the Officer Quality Composite of the Air Force Officer Qualifying Test (AFOQT). The stimulus material was a radar orientation programmed text. Results of the study were: (1) peeking did not reduce the effectiveness of programmed instruction; (2) students who responded covertly learned as efficiently as students who responded overtly; and (3) covert responding did not save instructional time.

320. Valverde, H. H., *Flight Simulators--A Review of the Research and Development*, Technical Report AMRL-TR-68-97, July 1968. AD 855 582.

This report presents a general review of the research and development of flight simulators and related areas sponsored by military and other Government agencies since 1949. The use of simulators for flight training is emphasized. The report does not consider mathematical models and space flight simulators. The topics include: (1) Visual and Motion Simulation, (2) Transfer of Training, (3) Utilization and Evaluation, and (4) Computers. An annotated bibliography of unclassified technical reports reviewed is included for each of the topics. The Defense Documentation Center accession number for each report is provided to facilitate the acquisition of copies of desired documents by United States military and Government agencies.

321. Valverde, H. H., *Learner-Centered Instruction (LCI): Vol. I A Systems Approach to Electronics Maintenance Training*. Technical Report AMRL-TR-67-208, July 1968. AD 846 721.

This report describes the proposed development and evaluation of a Learner-Centered (LCI) systems approach to electronics maintenance training. An electronics course, appropriate for airmen of various aptitudes, will be prepared to develop proficiency in the specific duties required of the Weapon Control Systems Mechanic/Technician (AFSC 322X1R) in the F-111A weapon system. The course will be developed within the environment of the weapon system development cycle, using data available during the time period and meeting of the demanding time schedules. The course will be highly job-relevant and will include multi-media, self-instructional, apprentice-like experiences. Personnel of various levels of aptitude in electronics, including levels lower than those currently used, will take the course. Their on-the-job performance will be carefully and systematically evaluated and compared with the performance of personnel from the parallel course. The total program will focus and demonstrate the technology for developing job specific, apprentice-like technical courses as an integral part of the weapon system development cycle. Also, the weapon control system equipment and Air Force training and course development procedures are described.

322. Valverde, H. H., *Maintenance Training Media--An Annotated Bibliography*, Technical Report AMRL-TR-67-151, May 1968. AD 673 371.

The training analyst must be able to specify training media requirements during the early stages of weapon systems development. Also, training specialists frequently need to make training media selections for center or base level courses. This report provides such personnel with information to assist them in the development of training equipment requirements. The selected annotated bibliography contains 200 references to Government sponsored training media research and development reports from 1950 through 1966. All of these reports are available through the Defense Documentation Center (DDC) to military agencies and their registered contractors. Each reference bears a DDC Accession Document (AD) number. Research and development reports on various technical aspects of training media (except operator training) which may be generalizable to maintenance are included; therefore, the information should be useful in other fields of technical training. The report describes, classifies, and graphically presents representative training media. The annotated bibliography contains references to (1) training media requirements, (2) training aids, including graphics, motion pictures, television and general training aids, (3) trainers, and (4) teaching machines.

323. Valverde, H. H. and Morgan, R. L., *Influence on Student Achievement of Redundancy in Self-Instructional Materials*, Technical Report AMRL-TR-68-75, December 1968. Also published in *Programmed Learning*, London, England, July 1970, pp. 194-199. AD 686 737.

Five versions of an instructional program on medical terminology were experimentally evaluated to determine the effect of redundancy or repetition on learning. The subjects (N=440) were assigned to five groups (N=88 for each group). The instructional materials for each group were as follows: Group I--274-frame linear program, Group II--160-frame linear program, Group III--83-frame linear program, Group IV--Narrative, typographically cued, text, and Group V--4 by 6-inch summary card. The instructional materials contained identical terminal behaviors. A 79-item multiple-choice test, which exhausted the population of behaviors, served as the achievement criterion. All groups studied the materials for an equal amount of time (3 hours).

Groups I and II did not differ in achievement. Groups III, IV and V also did not differ in achievement. Groups III, IV and V all were significantly superior in achievement to Groups I and II. Therefore, for certain learning outcomes, i.e., terminology and procedure following, programmed practice and review may detract from the effectiveness of self-instructional program.

ABSTRACTS FOR 1969

324. Askren, W. B., "Designing System to Fit Personnel Manning and Skill Capabilities," *Research and Technology Briefs*, Air Force Systems Command, Andrews AFB, Maryland, May 1969.

Man is an important parameter in Air Force systems, as demonstrated by his effect on system performance and cost. However, the human element has not been given proper value in decisions affecting design of systems. Although man accounts for approximately 50% of system performance and cost, the definition of his role in the system receives much less than 50% of the creative engineering effort expended during the development process. It was shown in this paper that man's capabilities, expressed as manpower quantities and personnel skill capabilities can be incorporated in the design process, and can have an effect on the configuration. It is concluded that a more adequate consideration of human resources during development would result in systems that are more cost-effective by making better use of the skills that Air Force personnel have acquired during years of training and work experience.

325. Askren, W. B., Bower, S. M. Schmid, M. D. and Schwartz, N. F., *A Voice-Radio Method for Collecting Human Factors Data,* Technical Report AFHRL-TR-68-10, January 1969. AD 686 059.

Available methods for collecting human factors data rely heavily on observations, interviews, and questionnaires. A need exists for other methods. The feasibility of using two-way voice-radio for this purpose was studied. The data-collection methodology consisted of a human factors analyst talking from a radio base station with technicians wearing portable radio units while they worked on jobs dispersed over an area. Verbal communication probed for information on equipment problems, procedural problems, delays and potential hazards. The concept of using radio equipment to collect human factors data was tested, using technicians performing flight-line maintenance. Data collected by radio were compared with data collected by questionnaire. It was concluded that voice-radio is not only a feasible means of collecting human factors data in the field, but has certain advantages over questionnaires in determining hardware problems and amplifying the data-collection capability of the human factors analyst.

326. Askren, W. B. and Regulinski, T. L., *Mathematical Modeling of Human Performance Errors for Reliability Analysis of Systems*, Technical Report AMRL-TR-68-93, January 1969. AD 687 084.

This research investigates the feasibility of modeling human performance errors in application to the reliability analyses of man-machine systems. The research addresses itself to time-continuous tasks with the derivation of a general mathematical model of the probability of errorless performance which is equated to human performance reliability. The application of this model and the implications of the time to first error concept were tested with a laboratory experiment using a vigilance task. The observed times to first miss error, times to false alarm error, and times to first combined miss and false alarm errors were ordered and, through classical inference theory, the underlying density functions were isolated. A number of distributions were tested for goodness of fit with the data. The Weibull, Gamma, and log-normal distributions emerged as relevant paradigms. The normal and exponential distributions were rejected. It was concluded that the derived general mathematical model of human performance reliability and the expected value of the random variable, time-to-first-human-error, are meaningful ways to quantify human performance of time-continuous tasks.

327. Askren, W. B., and Regulinski, T. L., "Quantifying Human Performance for Reliability Analysis of Systems" *Human Factors*, Vol. 11, No. 4, August 1969.

A general mathematical model of the probability of errorless human performance was derived and equated to human reliability for time-continuous tasks. The application of this model and the implications of the time-to-first-human-error (TTFHE) concept were tested with data collected using a laboratory vigilance task. The error data were ordered, and through classical inference theory the underlying density functions were isolated and tested for goodness of fit. Weilbull, gamma, and log-normal distributions emerged as relevant; normal and exponential distributions were rejected. The relevant distribution parameter values were applied to the general mathematical model, and predictions were made of human performance reliability for the task. It was concluded that this is a feasible and meaningful way to quantify human performance for time-continuous tasks for use in reliability analyses of systems.

328. Connelly, E. M., Schuler, A. R., and Knoop, Patricia A., *Study of Adaptive Mathematical Models for Deriving Automated Pilot Performance Measurement Techniques* - (Two Volumes) - Volume I - *Model Development*, Volume II - *Appendices*, AFHRL Technical Report 69-7, October 1969, Vol I - AD 704 597, Vol II - AD 704 115.

This report documents research on a new approach to deriving human performance measures and criteria for use in automatically evaluating trainee performance. The ultimate application of the research is to provide methods for automatically measuring pilot performance in a flight simulator or from recorded in-flight data. An efficient method of representing performance data within a computer is described. A system of adaptive mathematical and computer models is developed to examine representative performance data corresponding to known skill-levels and to independently develop a unique method of performance evaluation. Three types of models are developed, each of which is designed to derive and use (in an adaptive performance evaluation scheme) unique types of performance measures: (1) State-transfer measures, which are based on overall trends of the performance; (2) Absolute measures, which are based on a comparison of actual performance with some reference or standard; and (3) Relative measures, which are based on relations among various performance variables. A preliminary demonstration and an evaluation of the system are made, using a simulated aircraft landing model program to provide hypothetical test data.

329. Cotterman, T. E. "Training. . . . In 1980", *USAF Instructors Journal* Summer, 1969.

In 1980, training by the job will have been initiated in the Air Force. Training by the job means that the job which the individual is to perform is used along with his qualifications as the basis for the custom design of training that will be conducted.

330. Crites, C. D., *Miniature Event Recording as a Technique for Personnel Subsystem Test and Evaluation*, AFHRL Technical Report 69-16, September 1969 AD 700 100.

A study was performed to develop new Personnel Subsystem Test and Evaluation (PSTE) techniques for use during Categories I, II and III Testing of ground operator and maintenance functions. This report describes the development, modification, and refinement of a miniature event recording system as a PSTE technique. Equipment and operational procedures developed for the technique were evaluated under various conditions, including Category II Testing at an Air Force base. Results showed the utility of the event recording technique for quantitative task assessment and video tape data reduction. Specific recommendations are given for use of this technique from system concept through operational use.

331. Crites, C. D., *Press Camera with Polaroid Back Technique for Personnel Subsystem Test and Evaluation*, AFHRL Technical Report 69-17 September 1969, AD 700 101.

A study was performed to develop new Personnel Subsystem Test and Evaluation (PSTE) techniques for use during Categories I, II and III Testing of ground operator and maintenance functions. This report describes the development, modification, and refinement of a press camera system as a PSTE technique. Equipment and operational procedures developed for the technique were evaluated under various conditions, including Category II Testing at an Air Force base. Results showed the utility of the camera technique for human engineering and task assessment. Specific recommendations are given for use of this technique from system concept through operational use.

332. Crites, C. D., *Video Tape Recording as a Technique for Personnel Subsystem Test and Evaluation*, AFHRL Technical Report 69-18 September 1969. AD 700 102.

A study was performed to develop new Personnel Subsystems Test and Evaluation (PSTE) techniques for use during Categories I, II, and III Testing of ground operator and maintenance type functions. This report is concerned with the development, modification, and refinement of a video tape recording system as a PSTE technique. Equipment and operational procedures developed for the technique were evaluated under various conditions including Category II Testing at an Air Force base. Results showed the utility of the video tape recording technique for design and procedures development and training functions as well as for PSTE. Specific recommendations are given for efficient use of this technique from system concept through operational use.

333. Fligor, P. D., *Study of Data Sources and Processing for Radar Land Mass Simulation*, Technical Report AFHRL-TR-69-1. January 1969. AD 692 122.

To generate input data with a 50-foot resolution and fifteen shades of gray for advanced high-resolution digital radar simulators, this research examined and defined data sources and processing techniques. Limited to the Continental United States and to unclassified information, the data sources included all known aerial mapping imagery and topographic maps. All existing image processing techniques and devices were examined to define their operating principles. This review led to the conclusion that adequate geometric information for radar simulation data could be extracted from the current data sources and that existing processing capabilities could be combined into a feasible automatic system. In related work, non-parametric three-dimensional resections were calculated on a digital computer, and mathematical concepts were developed to give a computer system the capability of interpreting the physical characteristics in photos by using cues as done by a trained photo interpreter. Recommendations include examination of real imagery in statistically significant quantities to establish the probabilities of encountering given shape, size, and materials of objects in the real world; fabrication of a breadboard system to prove the operating concepts of a proposed image reader; examination of the communication between a computer's central processor and the reader device to optimize parallel processing for logical inference decision making; and after the verification of new concepts, the initiation of a design effort to culminate in an automatic processing system.

334. Herzberg, F. I., Winslow, E. K., and Majesty, M. S. *Motivational Engineering for Pilot Training*, AFHRL Technical Report 69-3 October 1969. AD 702 123.

This study was an investigation of student pilot motivation for, and attitudes toward, the Air Training Command's Undergraduate Pilot Training (UPT) program. The motivation-hygiene approach was used to systematically identify the motivational factors operating in the UPT program. This approach has been used extensively in industry and with success in a non-training military situation. This was the first time that the motivation-hygiene approach was used to investigate motivation in a trainee population. The purposes of the study were: (1) to employ motivation-hygiene theory and critical incident interview methodology for investigation of motivation in a military training situation, specifically, Undergraduate Pilot Training; (2) to compare the findings from the undergraduate Pilot Trainee sample with another Air Force sample and samples from industrial organizations. Once the motivational factors operating in the UPT program have been determined, the information can be used to design a "motivationally engineered" training program. Motivational engineering in UPT has the potential not only for improving student pilot performance, but also for reducing student pilot attribution. An Air Force documentary film, SPR-6-70, entitled Motivational Engineering for Undergraduate Pilot Training, summarizes the findings of this study.

335. Highcove, J., Stout, R., Hoberman, M. and Stellmach, A. T., *Base Engineer Automated Management System (BEAMS): Implementation/Conversion Team Education*, AFHRL Technical Report 69-21. October 1969. AD 701 390.

This report describes the nature, purpose and method of development of the Base Engineer Automated Management System (BEAMS) Implementation/Conversion (I/C) Team Education Course. It includes a short discussion of the content, history and development of BEAMS from its inception in 1964 to its initial test at Langley AFB in 1968. Implementation/Conversion is defined and described in terms of the responsibilities of major air commands and bases for the creation of the initial BEAMS data bank. The concept of the I/C teams is examined and the necessity for successful Implementation/Conversion is related to the success of the entire BEAMS program. I/C course content is contrasted with that of the regular BEAMS courses which were subsequently taught at AFIT, with special emphasis on the structure of course materials and teaching objectives.

336. Highcove, J., Kibbee, J., Stout, R. and Dominguez, L. F., *Base Engineer Automated Management System (BEAMS): Training at Sheppard Technical Training Center*, AFHRL Technical Report 69-24. December 1969. AD 702 866.

Instructional materials including plans of instruction, student workbooks, instruction guides, and simulated automated transactions were developed for use with hardware and software in courses of instruction designed to teach Air Force personnel to operate, maintain and utilize the base engineer automated management system (BEAMS). When supported by the necessary instructional materials for integrating them into organized instructional activities, simulations provide effective training systems.

337. Hill, J. W., Gardiner, K. W. and Bliss, J. C., *Design Study of a Tactile Cuing System for Pilot Training*, AFHRL Technical Report 69-12. August 1969. AD 697 991.

Several vibrator, air jet, and moving-button tactile stimulator-units were evaluated as cuing aids for pilot training in a manual tracking task. The best units, as determined by minimum mean square error and best operator describing function were built into a flight simulator. These units were further evaluated for their ability to help pilots control the trainer in some flight-simulation tracking tasks such as altitude holding and ILS landing. A one-dimensional tactile cuing system was designed using information obtained from these experiments. The cuing system, which consisted of two vibrators attached to the arms indicating heading error in excess of five degrees, was tested in a controlled experiment with four pilots having less than 200 hours of flight time. The two pilots using the cuing system learned significantly faster than the two pilots not using the system. This increased learning rate, however, was only seen when the pilots were engaged in side tasks such as problem solving and the taking of clearances. Plans for a more complete test of this cuing system and for possible extensions of cuing system to other aircraft variables are suggested. A selected review of the literature and current research was carried out to assess the feasibility and appropriateness of biostimulation and bioelectric control for pilot training and aircraft control.

338. Horton, J. A., and Bartucci, J. F., *Development of Lightweight Infinity Optics Display for Field Evaluation*, AFHRL Technical Report 69-13, August 1969. AD 696 696.

Goodyear Aerospace designed, fabricated and delivered a lightweight infinity optics display to the Air Force for attachment to a C-130E aircraft simulator and field evaluation by local personnel. Performance objectives were for a system providing a 54-deg by 41-deg field of view, 12-in. exit pupil, 6 percent distortion, 800 TV lines resolution, 5-ft-L brightness from a TV input; and ability to vary apparent viewing range from 100 ft to infinity. All objectives except for distortion were met. The final developed system consists of two large lightweight spherical mirrors, two large beamsplitters, two refractive correcting lenses, and a high-resolution high-brightness TV monitor that was specially developed during the program to fulfill the above requirements. The system as delivered represents a significant advance in the state-of-the-art for lightweight, low-cost visual simulation displays.

339. Horton, J. A., Emerick, R. M. and Mount, J. E., *Research in the Development and Application of Nonglass Optical Infinity Display Techniques for Visual Simulation*, Technical Report AFHRL-TR-69-2, July 1969. AD 639 651.

Infinity display possess many desirable properties that enhance the training value of aircraft flight simulators. In the past, little has been done to apply reflecting infinity display techniques to the problem of wide-angle visual simulation. This is primarily because glass mirrors were necessary to obtain the needed optical quality. These mirrors were heavy, fragile, expensive, and took a long time to manufacture. Additional support structures and control systems required by glass mirrors only added to the cost and complexity. Objectives of the nonglass infinity display research program were to study wide-angle display system concepts, develop high-quality non-glass mirrors and fabrication techniques, build a prototype display system, and define cathode ray tube characteristics needed for the display. A prototype unit using nonglass mirrors was fabricated having a 120-degree horizontal field of view and a 45 degree vertical field.

340. Kibbee, J. M., Highcove, H. E. and Harmon L. R., *An Education and Training Simulation of the USAF Base Engineer Automated Management System*, AFHRL Technical Report 69-28, October 1969. AD 702 122.

As part of an overall education and training program to instruct Air Force Base Civil Engineering personnel in the concepts and use of the Base Engineer Automated Management System (BEAMS), a simulation of the system was developed. This simulation, designated SIMA, covers a period of one week at a hypothetical Air Force Base, Hardnose AFB, and is intended to give the students an understanding of, and experience in, using BEAMS as part of their day-to-day activities at their bases. The simulation consists of a data base for Hardnose AFB, and a series of transactions that update the data base; the sequence and interdependency of the various transactions are described in an accompanying scenario. Because the simulation was specified for use in a number of different courses, oriented toward both management education and technician training, it was designed to be independent and self-contained, as well as modular. It can thus be easily adapted to any of the courses.

341. Kibbee, J.M., Vickman, L., Dent, Ellen, M. and Dominguez, L.F. and Stellmach, A.T., TOP-MAN-X: *A Management Simulation for Instruction in Total Programming and the Base Engineer Automated Management System (BEAMS)*, AFHRL Technical Report 69-20 September 1969. AD 704 892.

Top-Man-X, a management game developed primarily for the Civil Engineering School of the Air Force Institute of Technology at Wright-Patterson AFB, Ohio, is used to assist in the instruction of USAF personnel in Total Programming. Total Programming is a USAF developed set of concepts and procedures for the optimum allocation of resources to the operation and maintenance of real property facilities on an Air Force base. TOP-MAN-X is a manual "suitcase" management game. This report includes a short introduction to Total Programming, a discussion of TOP-MAN-X and the various steps in its development, and concludes with some remarks on the automation of both TOP-MAN-X and Total Programming.

342. Kincaid, Peter, J., *A Functional Model of Memory Based on Physiological and Verbal Learning Data*, Technical Report AFHRL-TR-68-16, April 1969. AD 694 078.

This report presents a functional model of memory based on verbal learning and physiological data. These diverse empirical data are used to describe several basic mechanisms of memory including: (a) separate mechanisms for short-term memory and long-term memory; (b) the initiation of long-term memory by short-term memory; (c) the properties of short-term memory including autonomous decay, distortion by interference, and a limited capacity; (d) the properties of long-term memory including a consolidation process dependent upon ribonucleic acid (RNA) and enzymes, and a very large capacity; (e) the functional grouping of items in long-term memory; and (f) consolidated (long-term) memories that are reactivated, being brought back into short-term memory. Time courses of these events are described. The ultimate benefits of a detailed knowledge of the mechanisms of memory is to help us to better understand how humans learn. This report describes how mnemonic techniques work and presents suggestions about how to improve memory training.

343. Knoop, Particia, A., *Application of a Simulation Analyzer Program for Deriving and Evaluating Numerical Integration Techniques*, Technical Report AFHRL-TR-68-9, March 1969. AD 687 854.

This report describes applications of a Simulation Analyzer Program for deriving or evaluating numerical integration methods for use in flight simulation for training. The FORTRAN program was developed in an earlier study, and its theoretical bases and capabilities are briefly presented in this report. The program is used to derive and evaluate optimal integration methods for application to a selected first-order and a second-order differential system. The program is used to derive and evaluate optimal integration methods for application to a selected first-order and a second-order differential system. The derived methods are used to solve these systems, and actual solution characteristics are compared with those predicted beforehand by the program. Characteristics of accuracy, actual percent error, stability, and error propagation are shown to be accurately predicted, as is the largest integration interval usable for each problem with each integration method. A thorough description is provided of the five popular simulation-integration techniques in use today and of a recommended procedure for using the Simulation Analyzer Program to derive new integration methods which allow maximization of the integration interval for specific simulation problems. As an example, the program is used to evaluate known methods and derive new methods for the F-100A problem using integration intervals of 0.5 and 0.10. A list of over 70 new integration methods derived by the program, including their stability and truncation-error characteristics, is provided.

344. Meister, D., Sullivan, D. J., Finley, D. L. and Askren, W. B., *The Effect of Amount and Timing of Human Resources Data On Subsystem Design*, AFHRL Technical Report 69-22, October 1969. AD 699 577.

The purpose of this study was to (1) determine whether the amount and timing of human resources data (HRD) influence design; (2) to investigate the effect upon design of differences in type of personnel requirements. Eight engineers were required to design the maintenance equipment for the AGM-69A, using equipment and HRD inputs produced for the actual equipment. One group received all HRD inputs plus stringent personnel constraints at the start of design; a second group received the same inputs plus "minimal" personnel constraints incrementally. It was found that the amount and timing of HRD inputs do influence design when these inputs are phrased as design requirements. The type of manpower requirement imposed also appeared to make some difference to subjects. Skill is considered by engineers to be of greater significance to system performance than numbers of personnel. Engineers prefer to receive their HRD inputs as early in design as possible. The estimates made by engineers of personnel required to operate and maintain their systems do not always seem to relate to their design concepts. Recommendations are made for the inclusion of personnel requirements in Requests for Proposal and Statements of Work. The need for additional research to describe the design implications of HRD inputs is pointed out, together with the desirability of using Air Force operational sites as a research laboratory.

345. Meister, D., Sullivan, D. J. Finley, D. L., Askren, W. B., *The Design Engineers' Concept of the Relationship Between System Design Characteristics and Technician Skill Level*, AFHRL Technical Report 69-23, October 1969. AD 699 578.

The purpose of this study was to investigate the relationships between design characteristics and skill dimensions. A series of paper and pencil tests developed to examine these relationships was administered to eight design engineers during two four-hour sessions. Design characteristics significantly related to skill level are test points, internal components, checkout and troubleshooting procedures, type of test equipment required and go/no-go displays. Individual design concepts such as component repair are also significantly related to the amount of training required. The engineer conceptualizes maintenance skill in terms of knowledge, troubleshooting ability and flexibiblity. The engineer's concept of skill level is more performance-oriented than that described by Air Force Specialty Code designations. Skill level appears not to be related in the engineer's mind to years of experience.

346. Neiberg, Alan, Morgan, Ross, and Levine, Marvine. "A Methodological Study of Incidental and Intentional Learning." *American Journal of Psychology*, 1969, 82(1), 117-121.

Two experiments are reported. Experiment I assessed the effect of instructions to learn numbers while sorting cards. In contrast to most research, the present study found that uninstructed S*s* learned the numbers as well as S*s* instructed to learn them. This finding was not directly affected by (1) postorientation testing, (2) sorting rate, or (3) prolonged exposure of the stimuli. In Experiment II, it was found that instructions to learn had no effect on retention over a 24 hour period even though S*s* instructed to learn required more time to sort the cards. These findings, *i.e.* that incidental learning is as effective as intentional learning while requiring less time, represent a successful replication and extension of earlier work of Saltzman.

347. Pieper, W. J., Folley, J. D., Jr. and Valverde, H. H., *Learner-Centered Instruction (LCI) Volume V - Description of the Job Performance Test*, AFHRL Technical Report 69-4, June 1969. AD 692 125.

A description is presented of the development of a job performance test for the Learner-Centered Instruction (LCI) Weapon Control Systems Mechanic/Technician, Air Force Specialty Code (AFSC) 322X1R course which was conducted at Lowry Air Force Base, Colorado from August through December 1968. The performance test was administered to the LCI experimental course subjects as well as the control course subjects upon graduation. The test will also be administered to these subjects in a field follow-up evaluation at Nellis AFB, Nevada, five months after graduation. The test items are, for the most part, based on tasks derived from the behavioral description of the actual job. The test contains three major parts: (1) Operational Checkout, (2) Troubleshooting, and (3) Auxiliary Task Performance. Most of the Test items are performed on the Simulated Maintenance Task Environment (SMTE), a simulator used for F-111A flight line electronics maintenance testing and training. The actual job performance test is not included in this descriptive report, however, sample items are presented. Since paper-and-pencil tests, in general, measure knowledge about the trainee's job rather than the ability of the trainee to perform required job behaviors, it is concluded that performance tests should be used to evaluate desired job terminal behaviors of training programs.

348. Pieper, W. J., Folley, J. D., Jr. and Valverde, H. H., *Learner-Centered Instruction (LCI):: Vol. VI--Course Methodology and Administration*, Technical Report AFHRL-TR-69-15, June 1969. AD 702 521.

A description is presented of an experimental Learner-Centered Instruction course for the F-111A Weapons Control System Technician (322X1R). The course differs from the conventional course as follows: (1) content of course materials, (2) type of training aids, (3) typical mode of instruction, (4) length of course, and (5) expected proficiency of graduates. Several instructional media and devices were used, including programmed books, teaching machines, and task simulators. The course was divided into the following seven major blocks: introduction, checkout, proceduralized troubleshooting, logical troubleshooting, other topics (Boresight; Remove and Replace), transition (from school to job), and whole-task practice. Each student proceeded through the prepared instructional materials at his own pace within each block. Air Force instructors presented the course at Lowry Technical Training Center. Eighty students, 40 with high (80-95) Airman Qualifying Examination (AQE) electronic scores and 40 students with medium (60-75) scores, attended the 14-week course. The higher-aptitude students took less time to complete the required materials, made an average of 10 percent fewer errors on the end of block tests, and learned to complete equipment checkout in less time than the medium aptitude students. Recommendations covering instructor orientation, training devices, method of instruction, student selection, troubleshooting materials, and equipment utilization are included. Evaluation of course effectiveness, in comparison with the conventional course is pending.

349. Regulinski, T. L. and Askren, W. B., "Mathematical Modeling of Human Performance Reliability," in the *Proceedings of the 1969 Annual Symposium on Reliability*, Chicago, Illinois, Institute of Electrical and Electronic Engineers, and IEEE Catalog No. 69C8-R, pp. 5-11, January 1969.

The preliminary results of research are presented, aimed at the feasibility of mathematically modeling human performance reliability. The study addressed itself to time continuous tasks with the derivation of a general mathematical model of the probability of errorless performance which is equated to human performance reliability. The application of this model and the implications of the time to first error concept were tested with a laboratory experiment using a vigilance task. The observed times to first miss error, times to false alarm error, and times to combined miss and false alarm errors were ordered, and through classical inference theory, the underlying density functions were isolated. A number of distributions were tested for goodness of fit. The Weibull, gamma, and log-normal distributions emerged as relevant paradigms. The normal and exponential distributions were rejected. Computer output of distribution parameters along with goodness of fit results are tabled. Comparison is shown of estimated and fitted means. It was concluded that the derived general mathematical model of human performance reliability, and the expected value of random variable, time-to-first-human-error, are meaningful ways to quantify human performance of time continuous tasks.

350. Rifkin, K. I., Pieper, W. J., Folley, J. D., Jr. and Valverde, H. H., *Learner-Centered Instruction (LCI): Vol. IV--The Simulated Maintenance Task Environment (SMTE): A Job Specific Simulator*, Technical Report AFHRL-TR-68-14, May 1969. AD 855 142.

The purpose of the Simulated Maintenance Task Environment (SMTE) is to provide a means for training and job performance testing of the flight line weapon control systems mechanic/technician for the F-111A aircraft (AFSC 322X1R). The SMTE provides practice in flight line equipment checkout, troubleshooting, and removal and replacement of line replaceable units in the resident training school or in the field. Also, it is used in conjunction with a performance test designed to measure the technician's ability to perform his job. The SMTE provides a high fidelity simulation of those characteristics of the task environment which the technician will encounter in the field while performing his job. It provides a capability for insertion of malfunctions and production of the appropriate out-of-tolerance display of fault indication. Failed units can be located, removed and replaced with performance requirements similar to those in the actual aircraft. The fact that the task has been broken down into part-tasks and that part-task training devices have been developed, permits the simultaneous training and testing of several individuals on different aspects of the job. The SMTE has an on-line event recording capability which makes a permanent record of control activations and the sequence of the actions. Because of the simulator's relatively low cost, it may be used frequently by students without incurring high replacement costs in the event of damage to components. It is easily repaired and does not require highly trained personnel to support it.

351. Semple, C. A. and Majesty, M. S., *Operational Tasks Oriented Flying Training Program for Pilot Training: The Systems Approach*, Technical Report AFHRL-TR-68-4, January 1969. AD 673 372.

The purpose of the study was to take a fresh and independent look at flying training requirements unhampered by the current training program and the traditional approach. The report presents a systems methodology for determining knowledges and skills common to piloting tasks required by differing aircraft-missions for the purpose of structuring a data base from which an operational tasks oriented flying training program could be developed. The general approach was to identify and classify the specific tasks performed by USAF pilots and the level of proficiency required on each task for successful performance in current and projected assignments in operational units using present and projected aircraft. The study was planned to encompass cross-system analysis and the integration of pilot tasks data into the Air Force Human Resources Laboratory's (AFHRL) computer based data bank. Therefore, inquiries across and within aircraft systems pertaining to piloting tasks, training requirements, and performance standards would be possible. Criteria for establishing common mission segments, tasks and cockpit subsystem hardware are presented. The technique for analyzing common tasks is presented in relation to assumptions regarding the type of training programs to which the data could apply. Rules for describing task activities and preparing the data for insertion into the computer based data bank are given.

352. Schumacker, R. A., Brand, Brigitta, Gilliland, M. G., Sharp, W. H. *Study for Applying Computer-Generated Images to Visual Simulation*. AFHRL Technical Report 69-14 July 1969. AD 700 375.

This report describes the results of a system design study for applying digital image generation techniques to visual simulation for pilot training. The computer generated images are to provide out-the-window scenes for a flight simulator which is to be used for training Air Force pilots. No existing visual system can provide all of the capabilities which are desired in a flight simulator. Digitally generated scenes do overcome many of the shortcomings associated with more conventional approaches but have had limited application because of the difficulty of computing enough image detail. The ability to generate images of more complex and realistic environments is closely tied to advances in digital device technology. The study assesses the impact of recent developments in this area on the design of an image generating system. The conceptual design of an image generator is described. The principles of operation, the system configuration and operational characteristics are discussed. Several key problem areas are explored in depth. Feasible methods of implementation with presently available hardware are examined and an estimate of the hardware complexity is given.

353. Snyder, M. T., Some Research on the Problems of Training Methods and Contents for Cross-Cultural Interaction, in the *Proceedings of the NATO Conference on "Special Training for Multilateral Forces"*, Brussels, Belgium, 22-26 July 1969.

The many problems of working with and understanding people of other cultures must be solved if counterinsurgency operations are to be successful. We in training research attack these problems through cultural learning and behaviors. Involved are at least two related problem areas, one of training methods and one of training content. Research on training methods concentrated on developments of improved methods for training Air Force personnel to perform effectively as instructors and advisors in foreign cultures. Specifically, this paper reports on the research, development and test of a new training technique for preparing personnel to perform civic action or mobile training team duties in foreign countries. The technique involved simulation and a particularly powerful form of feedback labeled "self-confrontation." In this technique, a videotape recording was made of a trainee's performance in a simulated cross-cultural setting involving interaction with a "counterpart" from the host culture. Immediately following each training trial or session, the trainee's performance was replayed for the trainee and his performance was critiqued by a cultural training expert. In both laboratory and field tests, this training method produced significantly more learning acquisition and retention of cultural interaction skills than other techniques. In addition, participants in the tests and the observers, all experienced Air Force officers, expressed much enthusiasm for the technique. Research on the second problem, that of training content, was performed in three ways: (1) by direct observation in the field of cross-cultural interaction; (2) through identifying those troublesome variables in cross-cultural interaction that are amenable to training; and (3) through models for handling and analysis of field data. Our social scientists participated in overseas missions to Africa and to Southeast Asia. The scientists on these missions gathered and analyzed cross-cultural interaction data primarily about interactions between our personnel and the host military and civilians in the country, paying special attention to data which seemed critical to the success of the mission and to development of rapport between personnel. Such data are important as content in the development of better training courses for teaching cross-cultural interaction skills and in isolating requirements for new research. In addition, the training content research included: (1) development and use of a transform model with static and dynamic processes for isolating dysfunctional cross-cultural behaviors attributable to heterocultural backgrounds of the interacting parties; (2) matrixes for elements of the American and indigenous cultural subsystems (human behaviors and conceptions caused by moral, political, economical and other processes or accustomed ways of doing things); (3) identification of interaction cases, i.e., case studies, and critical incidents with cultural analyses from the American and indigenous viewpoints; (4) use of the model for indicating training program content, handling cross-cultural data, generating and understanding the impact on motives and attitudes of social structure, power relationships, values and assumptions which underlie behaviors.

354. Soxman, E. J., Sharp, W. N., Orloff, K. L. and Tsiang, E. Y., *Development of Photoresistive Elements for an Analog Multiplier*, Technical Report AFHRL-TR-68-8, February 1969. AD 686 777.

Arrays of nine cadmium sulfide photoresistive cells each were developed for use in an analog multiplier. The program goals were to achieve a temperature coefficient of the photoresistance below 0.1 per cent °C, a voltage coefficient of the photoresistance less than 0.02 per cent per volt over a 10-volt range, and a response time of less than 10 msec. All photocells met the response time requirements; individual arrays met either the temperature coefficient or the voltage coefficient requirements. It was shown that the latter two characteristics tended to be mutually exclusive over the desired operating ranges. These differences could be reduced by increasing the photoexcitation intensity. An interpretation of this behavior was made in terms of the various competing electronic processes within a photoconductor. A description is given of the vacuum deposition, heat treatment, electroding and encapsulation processes used. The techniques used for measurement of the temperature and voltage coefficients over an extended range, the response time, the Hall effect and thermally stimulated currents are presented.

355. Taylor, R., Gerber, A., Allen, M., Brown, L., Cohen, E., Dunbar, D., Flexman, R., Hewitt, W., McElwain, D., Pancoe, E., and Simpson, D. *Study to Determine Requirements for Undergraduate Pilot Training Research Simulation System (UPTRESS)*, AFHRL Technical Report 68-11 July 1969. AD 858 640.

In order to provide a sound basis for the preparation of specifications defining the requirements for and undergraduate pilot training research simulation system (UPTRESS), a comprehensive study was made of all aspects of current and projected simulator technology and those techniques of simulation and training which appeared to offer the greatest utility for research purposes were analyzed in detail to determine the form and extent of the capability in each area (e.g. aircraft systems, simulation, motion simulation, visual simulation) which should be specified for the facility. To assure the Air Force widest possible latitude in its eventual selection of the capabilities to be provided in the facility, alternatives approaches of varying levels of complexity are described in a number of areas and the tentative preliminary design requirements set forth in each area are qualified as necessary to permit them to be considered in the light of subsequent decisions by the Air Force regarding research, objectives, training objectives, and level of expenditure.

356. Valverde, H. H. A Systems Approach to Electronics Maintenance Training. *Proceedings of International Symposium on Man-Machine Systems.* September 1969, Cambridge, England, IEEE Conference Record No. 69C58-MMS.

This paper describes the development and evaluation of an Air Force system-oriented electronics maintenance course for weapon control systems technicians. The objectives of the research effort were to: (1) demonstrate the technology for developing job-specific technical courses that are compatible with time schedules and data provisions associated with the development of weapon systems, (2) increase the efficiency of the training through the use of multi-media including automated instruction of an apprentice-like nature, (3) allow effective use of personnel of lower aptitude than those currently enrolled in electronics courses, and (4) determine experimentally its potential applicability.

357. Vickman, L., Harmon, L., Stout, R., Domingues, L. F., and Stellmach, A. *Base Engineer Automated Management System (BEAMS): Education at the Civil Engineering School*, AFHRL Technical Report 69-25. November 1969. AD 702 516.

Concurrent with the development of the Base Engineer Automated Management System (BEAMS), plans were developed for the education of Civil Engineer Management level personnel at the Air Force Institute of Technology (AFIT) in the operation and use of this new system. As an integral part of this education, a computer simulation was developed to provide the students with hands-on training and experience with BEAMS. The development of this simulation paralleled the development of BEAMS itself, and required modification on several occasions as BEAMS was altered in its development. The final version of the simulation was based on the October 1968 version of BEAMS and in March 1969 replaced prototypes which had previously been in operation at AFIT. The simulation was designed to create the conditions, atmosphere and operational situations that would be prevalent at a typical Air Force base operating under the BEAMS concept. It was designed to take place over a period of one week and to encompass most of the actvity which might reasonably be expected to occur in Civil Engineering organizations at bases anywhere in the world. AFIT students were required as a part of their simulation training to use a remote terminal keyboard/printer to perform various clerical processes required by the simulation. The purpose of this participation was to increase their knowledge and understanding of BEAMS, and to add to their motivation and enthusiasm in the implementation and use of the system.

358. Williams, R. H., Talbert, G. E., Cockran, T. C., Jr., Potter, K. W. *Overall Application of Computer Technology to the Education and Research Programs of Air University*, AFHRL Technical Report 69-8 December 1969. AD 703 730.

The determination of the overall application of computer technology to the education and research activities of Air University was undertaken by the study team. This problem required that the need for computer assistance throughout the University be assessed. Further, it required the need for computer assistance to be translated into a set of adequate system requirements. Twenty-five units of Air University were identified for individual in-depth study. Upon completion of each study, a document was prepared, reviewed, revised and published. This activity constitued Phase I of the study. The information thus collected provided the data required for analysis. The analysis, performed within Phase II, indicated the set of functional education and research activities which were amenable to and would benefit most from the application of computer assistance. Further analysis identified the computer-based functional capabilities required. The conclusion derived from this analysis activity is that Air

University should start action to procure an on-line interactive time-shared primary mission computer system which is capable of background production with batch processing availability. This Technical Report details the findings of the entire study. Recommendations regarding the system components - equipment, software and personnel are enumerated. Suggested system configuration options are identified, of which each is capable of providing the required application of computer technology to the education and research activities of Air University.

359. Wood, M. E., "Continuously Adaptive versus Discrete Changes of Task Difficulty in the Training of a Complex Perceptual-Motor Task," *Proceedings, 77th Annual Convention, American Psychological Association*, 1969, pp. 757-758.

Two groups of subjects learned a two-dimensional, second-order, compensatory tracking task. One group was trained under continuously adaptive conditions; difficulty was automatically varied so that error was held constant. A second group was trained under a schedule of increasing levels of fixed difficulty. The results showed that increasing levels of fixed difficulty provided generally superior performance. The inferiority of the continuously adaptive condition may be at least partly due to mismatches between the subject's skill and the adjusted task difficulty that occur when the subject's skill appears to oscillate from time to time.

ABSTRACTS FOR 1970

360. Askren, W. B., and Valentine, R. I. Effects of Field Experience on Instruction. *USAF Instructors Journal*, Vol VIII, No. 1, Summer 1970.

The Air Force Air Training Commands' concept that a high percentage of technical instructors should be field-experienced is described. Results from the first phase of a research program indicate that although technical school supervisors prefer field-experienced instructors, these instructors are not better teachers that instructors without field-experience.

361. Askren, W. B., Valentine, R. I., *Value of Job Experience to Teaching Effectiveness of Technical Training Instructors*, AFHRL Technical Report 70-8, June 1970. AD 709 876.

Air Force Technical training instructors with and without field job experience were compared regarding teaching effectiveness. Effectiveness was measured by student grades, student written critiques, and supervisor ratings. Results indicate no significant difference between instructors on student overall course grades and critiques. However, an interaction effect exists between type of instructor and phase of course. Supervisors rate job-experienced instructors higher.

362. Eckstrand, G. A., "Research on Pilot Training by the Air Force Human Resources Laboratory," *Proceedings of the First Annual Psychology in the Air Force Symposium*, U.S. Air Force Academy, April 1970.

A brief overview is provided of R&D on pilot training being carried out by the Air Force Human Resources Laboratory. One effort is the development and validation of on-board recording equipment to assess the flight performance of Undergraduate Pilot Trainees. Another effort involves the application of the systems approach to the development of crew training. A description is provided of studies pertaining to the design and use of simulators for flight training. Information is provided about the design, evaluation and potential applications of a system for obtaining audio-video recordings of in-flight pilot performance.

363. Faconti, V., Mortimer, C. P. L. and Simpson, D. W., *Automated Instruction and Performance Monitoring in Flight Simulator Training*, AFHRL Technical Report 69-29. February 1970. AD 704 120.

This report documents research in the area of Automated Instruction and Performance Monitoring. One objective of the research was to develop modular approaches to implementing eight individual automated training capabilities in flight simulators. Several approaches to each area are identified and briefly investigated. More complete investigation, including programming flow diagrams and hardware and software estimates, is presented on those approaches in each capability areas which appeared to be most feasible. Two integrated systems, i. e. systems which include all eight automated training capabilities, are "designed". Selection of the components for each of the systems is made by assigning levels of relative complexity to each approach in each area. System one is designed by using the lowest complexity approach in each area while system two consists of the highest. Several methods of implementation, in relation to the computer complex, are presented. These varied from including the instructional system in the basic simulation programs to the addition of satellite computers to handle the instructional function. Estimated implementation costs are given for the two systems for each selected computer configuration and two display system options.

364. Fligor, P. D., *Analysis of Data Density and Storage Requirements for High Resolution Radar Simulation System Design*, AFHRL Technical Report 70-12, June 1970. AD 711 385.

The state-of-the-art was sampled to determine whether modern, commerically available computers with mass data storage units offered the potential for simulation of the performance of high-resolution radar systems. This effort was primarily concerned with the data storage for urban areas since such areas would place the severest burden upon the digital storage and computation system. Selected areas of New York City and San Francisco were analyzed from aerial photographs, and 74,000 dimensional readings were taken to form the basis for the conclusions given in this report. The analysis of results based upon extrapolations indicated the feasibility of system simulation from the standpoint of data storage and access time of modern computers.

365. Foley, J. P., Jr. Aids to Reliable Performance, *USAF Instructors Journal* Spring, 1970.

Describes a new concept for the development and display of step-by-step maintenance instructions called job performance aids. This concept is compared with the cookbooks used by housewives for many generations. Discusses the possible impact of this new concept on training for maintenance jobs in the Air Force.

366. Fowler, V. J., and Reich, S. M., *Wide-Angle Rotating-Mirror Scan System for Use in Laser Display System*, AFHRL Technical Report 70-32 November 1970. AD 721 449.

This program covers the design development and fabrication of a wide-angle rotating mirror scanner for use in laser display systems. A hysteresis synchronous motor designed for operation at 300,000 rpm and employing gas bearings was fabricated and tested. Operation to 240,000 rpm was achieved with ball bearings, while limited success was obtained with gas bearings. In addition, hydrostatic gas-film-lubricated bearings made from copper impregnated tungsten were fabricated and tested.

367. Klamm, R. L., Jacobs, D., and Clark, H. J., *Training Potential of In-Flight Audio/Visual Recording Equipment for the F-4E Aircraft*, AFHRL Technical Report 70-25 December 1970. AD 720 245.

This report presents a detailed description of an Audio/Video Recording System developed to study the feasibility and training potential of inflight video recordings through the gunsight and of the instrument panel of an F-4E aircraft. The purpose of the study was to assess the value of the system as an aid in air-to-air and air-to-ground gunnery training. Flight tests were conducted in an F-4E aircraft at Nellis AFB, during which air-to-air and air-to-ground weapon delivery missions were recorded. Results of the tests proved the value of audio/video recording for training and mission evaluation, but indicated a requirement for a higher resolution video system. Additional advantages and limitations of the equipment and the tape recordings obtained are described, and it is recommended that additional tests be made with equipment capable of producing higher resolution video tapes.

368. Pieper, W. J., Swezey, R. W. and Valverde, H. H., *Learner-Centered Instruction (LCI) Volume VII. Evaluation of the LCI Approach*, AFHRL Technical Report 70-1. February 1970. AD 713 111.

The evaluation of the Learner Centered Instruction (LCI) approach to training was conducted by comparing the LCI F-111A Weapons Control System Mechanic/Technician course with the conventional Air Force course (ABR 32231R) for the same Air Force Specialty Code (AFSC) 32231R on the following dimensions: (1) job performance of course graduates, (2) man-hour and dollar costs of the two courses, and (3) student acceptability and instructor problems for the LCI course. Measures of job performance included a job performance test, an Air Force practical test, the supervisors' ratings, and a substitute job knowledge test. The graduates were measured both at end-of-course and again after five months in the field at field followup. The high aptitude LCI trainees' job performance was superior to the high aptitude conventional course trainees. Costs in terms of manhours and dollars for the LCI course were substantially lower than those for the conventional course. The LCI course was about equally acceptable to the high and medium aptitude trainees but some of the instructors had misgivings about the LCI approach. This report includes implications of integrating LCI courses into the Air Force training environment.

369. Potempa, K. W., Talcott, D. R., Loy, S. S. and Schwartz, N., *Videotape as a Tool for Improving Human Factors Test and Evaluation Activities*, Presented at "Second Tri-Service/NASA Personnel Subsystems-Human Factors Test and Evaluation Conference", February 1970, in Los Angeles, California. AFHRL-Technical Report 70-6, May 1970. AD 708 505.

Analysis of the literature has indicated that fairly unsophisticated methods are generally used to collect human factors test and evaluation data in the field. The most commonly used methods being direct observation, interview, and questionnaires. One technique which is being looked at to expand our capabilities is video tape recordings. The uses of this technique to collect data on both maintenance and aircrew performance is being examined. The videotape equipment being used to study aircrew performance was custom made in order to fit the unique requirements of flight environment. The utility of this system for collecting human factors test data is currently being evaluated in the F-4E Category II test program at Edwards AFB. The data obtained from the videotapes on pilot activity is being compared with that obtained from pilot interviews in terms of accuracy of information, kinds of information each method is best suited to provide, and the number and kinds of human factors decisions which each technique best facilitates. In addition, methods of integrating the use of both methods in field tests are being studied. The TV equipment used in collecting maintenance data consisted of standard commercial items but a number of packaging innovations were made to increase their portability. This study, which also used the F-4E as a test bed, pointed up many of the advantages and limitations of videotape as a data collection tool.

370. Rhode, W. E., Esseff, P. J., Pusin, Carol, J., Quirk, F. B., and Shulik, R., *Analysis and Approach to the Development of an Advanced Multimedia Instructional System,* AFHRL Technical Report 69-30, Vol I. May 1970. AD 715 329.

In order to examine the possibilities for an advanced multimedia instructional system, this study begins with a comprehensive review and assessment of current instructional media in terms of (1) a functional description, (2) instructional flexibility, (3) support requirements, and (4) costs. Following this, a model of an individual instructional system is developed as a basis for further analysis. Final comparison and "trade-offs" among the media are then made to arrive at a recommended media configuration which could serve as a multimedia base for an individualized instructional system. At this point, requirements and features of an automated management information and control subsystem to provide necessary operational control of the total instructional system are outlined and discussed. Finally, the main features of a generalized plan for the development of such a system are described.

371. Rhode, W. E., Esseff, R. J., Pusin, Carol, J., Quirk, F. B., Shlik, R., *Analysis and Approach to the Development of an Advanced Multimedia Instructional System (Appendix III - Media Cost Data),* AFHRL Technical Report 69-30, Volume II. May 1970. AD 715 330.

The principal data in support of the study described in Volume I (Reference 370) are tabled herein.

372. Schumacher, S. P., Rudov, M. H. and Valverde, H. H., *Evaluation of a Low Cost In-Flight Audio/Video Recording System for Pilot Training,* AFHRL Technical Report 69-31. January 1970. AD 709 213.

This report describes a study to determine the feasiblity and effectiveness of using in-flight audio/video recording and ground playback equipment in the United States Air Force Undergraduate Pilot Training (UPT) Program. It includes a detailed description of a low cost Audio/Video Recording System (AVRS) which was developed for the study. Audio/Video equipment configurations are discussed as they apply to training operations in the T-37 aircraft. A description is given of the training methodology which was formulated for integrating the audio/video recordings of student maneuvers into flight training program. Airborne cameras were used to view the flight instruments and the pilot's forward outside scene. The operational use of the AVRS is described for two on going classes of pilots. Each class was comprised of two matched groups of students, one of which was trained with AVRS (TV students), and one of which was trained in the normal manner. The results in terms of differences in achievement levels and learning rates for the TV and non-TV students are described. Conclusions as to high equipment reliability and easy maintainability and the training benefits which can be expected to accrue from use of the AVRS are detailed. Finally, recommendations are presented for the improvement and implementation of the AVRS as an instructional tool.

373. Smith, E.A. and Kincaid, J. P., *Derivation and Validation of the Automated Readability Index for Use with Technical Materials*, Human Factors, 1970, 12 (5), 457-464, also identified as AFHRL technical report 70-47, AD 716 314.

The utility of technical materials is influenced to a marked extent by their reading level or readability. This article describes the derivation and validation of Automated Readability Index (ARI) for use with technical materials. The method allows for the easy, automatic collection of data as narrative material is typed on a slightly modified electric typewriter. Data collected includes word length (a measure of word difficulty) and sentence length (a measure of sentence difficulty). Appropriate weightings of these factors in a multiple regression equation result in an index of reading difficulty. Uses of the index for evaluating and controlling the readability of large quantities of technical material are described.

374. Taylor, C.L. and Eschenbrenner, A. J., Jr., *Forward Air Controller Visual Reconnaissance Training Manual*, February 1970. AD 867 841.

This manual was developed jointly by Air Force Avionics Laboratory and Air Force Human Resources Laboratory for use in a forward air controller visual reconnaissance training research program. The narrative content of the manual was developed from existing manuals and critical incidents interviews. The use of verbal materials was held to a minimum. To increase training efficiency, pictorial materials were used extensively.

375. Taylor, C. L., Eschenbrenner, A. J. Jr., and Valverde, H. H., *Development and Evaluation of a Forward Air Controller (FAC) Visual Training Program*, AFAL Technical Report 70-190, September 1970. Joint AFAL/AFHRL Study. AD 875 848.

This report describes the development and evaluation of a prototype program for training Forward Air Controllers (FACs) in the basic skills of detecting, recognizing, and identifying limited war/counterinsurgency (LW/COIN) targets. An analysis and specification of the essential elements of the FAC visual reconnaissance task was accomplished. A prototype training program, in the form of a manual containing photographs and sketches of LW/COIN targets and integrative textual materials, was developed to teach FAC skills related to target detection and identification. (See Abstract Number 372). The prototype training program was compared with the conventional training program within the context of a two-group experiment and recommendations were made for incorporating the prototype training program into the present training curriculum.

376. Valverde, H. H., *Innovations in Air Force Technical and Flying Training*, AFHRL Technical Report 70-13, June 1970. Professional paper presented at the Symposium on Evaluation of Educational Technology Applications, 22-26 June 1970, U.S. Naval Academy, Annapolis, Maryland, AD 707 511.

Two innovations in technical and flying training are described. The first is an application of the systems approach to electronics maintenance training. The systems approach resulted in a fourteen-week course. The conventional course required twenty-four weeks. Graduates of the two courses were compared on various criteria. The systems approach seems to produce a graduate who is better able to perform the operational job; however, they are less proficient on standardized tests of electronics proficiency. The second effort pertains to the development and evaluation of audio/video recordings in undergraduate pilot training. Equipment mounted in the aircraft produced audio/video recordings that were of substantial help to the students when viewed after flight.

377. Valverde, H. H. and Roberts, R. E., *A Responder for Use in Programmed Lectures*, AFHRL Technical Report 70-5, May 1970. AD 708 504.

This report describes the student responder and presents information as to how the device may be used to obtain student responses during programmed instruction lectures. In Air Force flying and technical training programs, the device can be especially useful in lecture/slide presentations designed to teach need-to-know information. Unlike any other responders, this device can be used in a dimly lit or darkened classroom during slide presentations; when multiple-choice questions are projected on the screen, the student responses are illuminated and thus can be seen clearly by the instructor. The parts required to build the responder are identified and the prices of the parts listed, and a step-by-step procedure for constructing the device is presented.

378. Weed, H. R., Smith, Marion L., Frasher, R. D., *Educational Program for Scientists and Engineers at Wright-Patterson Air Force Base*, AFHRL Technical Report 69-9, January 1970. AD 702 867.

This contract, a pilot study of Project Innovate Task C, calls for development of programs to update Air Force scientists, engineers, senior technicians, and managers of science and engineering, both military and civilian, who work in research and development at Wright-Patterson Air Force Base. The programs shall provide current knowledge and information to professional employees to help them stay abreast of rapidly advancing technology in their own and related specialties. Phase I reports identification of needs and available training programs. Needs in continuing education were assessed from: (1) existing personnel and training records, (2) questionnaries distributed to all appropriate personnel at WPAFB, (3) personal interviews with five percent of engineers and scientist, and (4) group interviews with management personnel of all laboratories and divisions. While present level of participation in educational and training programs is sizable, there is a clear need for greatly expanded educational programs. The nature of these needs and suggested methods for meeting them at WPAFB is described. The Phase II lists recommendations for educational programs to meet the continuing education needs at Wright-Patterson Air Force Base and suggests the administrative organization for implementing these programs.

ABSTRACTS FOR 1971

379. Askren, W. B., Human Resources Data In System Analysis and Design. *Air Force Research Review*, No. 1, Air Force Systems Command, Andrews Air Force Base, Washington DC, January-February 1971.

Research is described which has as its goal the development of a technology which will allow the integrating of data on the human resources of the Air Force with engineering, logistical, and operational requirements in system design activities. Results have identified the kinds of human resources data which are useful in the system development process, have determined that it is feasible to impose human resources data as constraints on the design engineer, have determined what effect these constraints have on system characteristics, and have determined the elements of a procedure for integrating human resources data in the system development process.

380. Askren, W. B. and Regulinski, T. L., *Quantifying Human Performance Reliability*, Presented at the Psychology in the Air Force Symposium conducted at the Air Force Academy, Colorado, 20-22 April 1971. AFHRL-TR-71-22, June 1971. AD 727 766.

Human performance reliability for tasks in the time-space continuous domain is defined and a general mathematical model presented. The human performance measurement terms time-to-error and time-to-error-correction are defined. The model and measurement terms are tested using laboratory vigilance and manual control tasks. Error and error-correction data are ordered and the underlying density functions isolated. The Weibull distribution is best fit for time-to-first-error data, and the Log-Normal distribution is best fit for time-between-errors and time-to-error-correction data. The normal distribution is rejected in all cases. Distribution parameter values are applied to the general mathematical model, and prediction made of human performance reliability for the tasks. It is also shown that task performance reliability improves with training on the tasks.

381. Askren, W. B. and Korkan, Kenneth D., *Design Option Decision Trees. A Method for Relating Human Resources Data to Design Alternatives*, AFHRL-TR-71-52, December 1971. AD 741 768.

The feasibility of predetermining the design options available to the engineer during system design and placing the results in a decision tree format was investigated. Design option decision trees for propulsion and flight control subsystems were developed. The decision trees were evaluated by eight engineers experienced in designing the specialized areas of aerospace systems. It is concluded that the decision format is a feasible and valid method for describing system design options. It is hypothesized that Design Option Decision Trees may provide a means for relating human resources data to specific design characteristics. However, a number of additional investigations are needed to develop and validate a workable technique for using DODT's as a method for including human resources data in design decisions.

382. Baldwin, T. F. and Bailey, L. J., "Readability of Technical Training Materials Presented On Microfiche vs Offset Copy", *Journal of Applied Psychology*, 55, (1), 37-41, February 1971.

An experiment was conducted to determine the influence of the mode of presentation of reading material upon the reader's performance. The modes of presentation were: offset or hard-copy, positive image microfiche (black on white) and negative image microfiche (white on black). The subjects were in Personnel Awaiting Training Status at Chanute Air Force Base. They were randomly assigned to one of three groups of 43-45 subjects each. Groups were equivalent on the Armed Forces Qualification Test. Each subject performed twelve tests, representing four different types of reading materials. The four types were: narrative text, schematics or diagrams, detailed figures or symbols, and charts or maps. The tests ranged in duration from three minutes to fifty minutes. Testing required approximately four hours. Three different sequences of tests were used within each group and 10-20 minutes rest periods were allowed after each hour of testing. On three tests, subjects performed somewhat better using hard-copy (offset). These tests especially required reading of detailed figures. Performance of all groups on all other tests was highly similar. The general conclusion is that microfiche is about as "readable" as hard-copy for most training materials. Further research should explore longer use of microfiche, methods and equipment for improving the efficiency of reading microfiche and making microfiche reading more desired by trainees.

383. Chenzoff, A. P., Mallory, W. J. and Joyce, R. P., *Guidance and Specification for the Preparation of Fully Proceduralized Job Aids for Organizational and Intermediate Maintenance of Electronic Subsystems*, AFHRL Technical Report 71-23, June 1971. AD 731 144.

This report supplies a model for specifications for the preparation of fully proceduralized job aids for organizational and intermediate maintenance of electronic subsystems and offers guidance in the preparation of such aids. The aids to be developed from these specifications are for flight-line or field-shop maintenance of any electronic subsystem, and support the performance of the following maintenance functions, as needed: checkout, alignment, repair, adjustment, calibration, malfunction localization, malfunction isolation, and the removal and replacement of malfunctioning equipment items.

384. Colwell, M. C., *TREES: A Computer Software System for Processing Data Organized in Branch Form (An Application to Job Performance Aids) Volume I: Design and Development*, AFHRL Technical Report 71-26 (I) June 1971. AD 732 204.

This document describes the development of computer programs for loading, editing, maintaining, and querying tree-structured data bases. Loading and maintaining data bases can be achieved interactively or in the batch mode. Querying and editing are done in the interactive mode only. A pre-requisite to the development of the computer programs was the development of tree-structured data base concepts.

385. Colwell, M. C. and Risk, Darlene M., *TREES: A Computer Software System for Processing Data Organized in Branch Form (An Application to Job Performance Aids) Volume II: Program Descriptions*, AFHRL Technical Report 71-26 (II) June 1971. AD 735 603.

This report describes five computer programs which provide step-by-step guidance through tree-structured data files. Together, these five programs constitute TREES. The five programs are: (1) QUERY - for interacting with a tree-structural data base from a remote terminal; (2) BUILD for loading data from a remote terminal: (3) EDIT - for editing a modifying existing data base from a remote terminal; (4) BUMP - for loading and maintaining data bases in the batch mode; and, (5) LOADS - for loading and maintaining standard statements in a batch mode. This Volume is intended for programmers who may wish to apply, expand, or revise any of the features of the TREES Computer Programs. Volume I of this report describes the design and development of TREES.

386. Colwell, M. C., Risk, Darlene, M. and Reed, L. E., *TREES User's Guide - A Computer Software for Handling Information in Branch Form*, AFHRL Technical Report 71-27. June 1971. AD 732 209.

Instructions are presented for interactive and batch computer programs that process tree structured (TREES) data. These instructions were prepared as part of an overall effort to develop techniques for a computer based job performance aid. The QUERY program, which operates from a remote computer terminal, provides step-by-step guidance through maintenance troubleshooting trees. Data files may be created and maintained from a remote terminal using programs BUILD and EDIT, respectively. Large data bases are stored and maintained with program BUMP and standard phrasing of text material is stored in the data base with program LOADS. Instructions for the interactive programs were prepared so that an individual with little or no computer experience may create, modify, and query his own data base. Keypunching instructions are given for the batch processing programs. The five programs have sufficient flexibility for application to many forms of tree-structured data, including flow diagrams, instructional material, or any other forms in which step-by-step guidance is needed through decision points.

387. Connelly, E. M., Schuler, A. R., Bourne, F. J. and Knoop, Patricia A., *Application of Adaptive Mathematical Models to a T-37 Pilot Performance Measurement Problem*, AFHRL Technical Report 70-45, January 1971. AD 726 632.

This report documents experimental research on a new method of deriving performance measures and criteria for use in automated pilot performance evaluation. Data recorded on board a T-37B aircraft (tail number 58-1948) were submitted to a previously implemented system of adaptive mathematical models (AMM). The results were analyzed to determine the practical capability of the AMM in automatically deriving measures and criteria. Flight data for a series of performances of the Lazy 8 and Barrel Roll maneuvers were processed first by a set of Boolean functions. These functions describe the data in the form of Boolean time sequences (BTS), which are then operated upon by the AMM to derive three types of performance measures: (1) State Transfer Measure, which are based on overall trends in the performance; (2) Absolute Measures, which are based on a comparison of actual performance with some reference; and (3) Relative Measures, which are based on relations among performance variables. The results show that the AMM system can be used to effect a systematic attack on the problems of performance measurement using representative flight data. Face-validity of measures derived by the AMM is illustrated by comparison with performance evaluations made by an instructor pilot.

388. Folley, J. D., Jr., Joyce, R. P., Mallory, W. J. and Thomas, D. L., *Fully Proceduralized Job Performance Aids: Volume I - Draft Specification for Organizational Maintenance*, Technical Report AFHRL-TR-71-53(I), December 1971. AD 704 903.

This report supplies a model for specifications for the preparation of Fully Proceduralized Job Performance Aids for the organizational maintenance of Air Force man-machine systems. The model reflects the research findings of AFHRL and other DoD agencies concerning maintenance data. It has the unique feature of requiring that certain subproducts necessary for the development of this type of data be prepared in a standard format and submitted for review by the procuring agency. These subproducts include items such as a task identification matrix, task inventory, a task description index and management matirx, and task step data details. The aids to be developed from these specifications are for the *organizational* maintenance of any man-machine system and support the performance of the following maintenance functions: checkout, alignment, repair, adjustment, calibration, malfunction isolation and the removal and replacement of malfunctioning equipment items. It calls for the preparation of the aids in several options of job guide format.

389. Folley, J. D., Jr., Joyce, R. P., Mallory, W. J., and Thomas, D. L., *Fully Proceduralized Job Performance Aids: Volume II - Developer's Handbook*, Technical Report AFHRL-TR-71-53(II), December 1971. AD 744 007.

This report provides guidance for the development of fully proceduralized job performance aids for the organizational maintenance of Air Force man-machine systems. It contains detailed instructions for preparing fully proceduralized job performance aids in accordance with the requirements of the draft specification contained in Volume I of this technical report. It includes instructions for performing the behavioral task analysis and for converting the results of the analysis into effective performance aids. In addition, it presents a strategy and guidance for developing supervised practice exercises designed to produce the skills required to prepare fully proceduralized job performance aids.

390. Hawkins, J. E. and Valverde, H. H., *Introduction to Multisensor Reconnaissance*, Air Force Avionics Laboratory (AFAL) Technical Report 71-43, June 1971. AD 733 347.

This document presents a comprehensive, but practical, introduction to multisensor usage in aerial reconnaissance. It covers primarily the current and conceptual multisensors operating in electro-optical and micro-wave regions of the electro-magnetic spectrum, the various types of aerial reconnaissance/surveillance missions, and the factors to be considered in utilizing these sensors for such missions. The document also includes a bibliography and an extensive glossary to cover all reconnaissance-oriented nomenclature.

391. Joyce, R. P., Folley, J. D., Jr. and Elliott, T. K., *Fully Proceduralized Job Performance Aids: Volume III - JPA Manager's Handbook*, Technical Report AFHRL-TR-71-53(III), December 1971. AD 744 817.

This report provides guidance for the Air Force Data Managers charged with the responsibility for the procurement of fully proceduralized JPAs. It provides guidelines, suggested procedures, and checklists for use by data managers in the review and assessment of the subproducts, intermediate products and JPAs produced in accordance with the draft specification contained in Volume I of this technical report.

392. Juhlin, J. A., *Study to Define the Interface and Options for the Advanced Simulation in Undergraduate Pilot Training Visual Simulator*, AFHRL-TR-71-47, September 1971. AD 739 585.

As a result of recent Air Force decisions regarding the Advanced Simulation in Undergraduate Pilot Training (ASUPT) Flight Simulator requirements and configurations, the need for additional definition of the visual subsystems interface parameters became apparent. It was also recognized that certain new features to improve the system operational flexibility and performance needed further study and definition.

In the study to define the interface and options for the ASUPT visual simulator, four major areas were investigated. These specific areas are: a. CRT Electronics Definition, b. CRT Electrical Characteristics, c. Display Multiplexing and d. Edge Smoothing.

The CRT Electronics Definition and the CRT Electrical Characteristics investigations concentrated on establishing feasible design parameters consistent with system performance requirements and on identifying a compatible interface between the CRT (including focus and deflection coils) and the Display Electronics. The CRT Electronics Definition included sweep generator and deflection amplifiers, linearity correction circuits, and dynamic brightness as well as focus circuits, video amplifiers, and power supplies. The Display Multiplexing and Edge Smoothing investigations were directed toward concept definition of optional features to improve the system operational flexibility and performance.

The Display Multiplexing investigation resulted in the definition of two approaches for driving two cockpit displays with one image generator referred to as Time Multiplexing and Edge Capacity Multiplexing. In the Time Multiplexing concept, the computed image generator alternately updates each cockpit display subsystem resulting in a reduction of the update rate from 30 updates per second to 15 updates per second while still refreshing the 2:1 interlaced display at 30 times per second to prevent flicker. The edge capacity concept shares the system scene content capacity in each cockpit display. The subjective evaluation of motion discontinuities associated with the reduced update rate inherent in time multiplexing demonstrated that severe operational constraints would be imposed if this technique were implemented. The Edge Smoothing study evaluated several techniques for improving the discontinuities in edges intersecting the raster lines at angles other than 0 to 90 degrees. The results of this study indicate that when all the techniques are simultaneously applied, the residual effect is negligible.

393. Lintz, L. M., Askren, W. B. and Lott, W. J., *System Design Trade Studies: The Engineering Process and Use of Human Resources Data*, AFHRL Technical Report 71-24, June 1971. AD 732 201.

The purpose of the study was to investigate the system design trade study process, and to determine the feasibility and effects of integrating data on the human resources of the Air Force in this process. Sixty one completed trade studies from aeronautical, missile, and command, and control systems were analyzed to determine the nature of engineering design trade studies. Four simulated trade studies representing flight control and avionics subsystems containing engineering and human resources data were constructed for experimental use. Seventy two experienced design engineers performed the simulated trade studies. It was found that engineers can and do use human resources data in system design trade studies, and that such data should be presented in tabular form, in quantitative fashion and in units familiar to the engineer to be most useful. It was also found that there are four major sources of variability in trade study results, namely, choice of parameters to be included, weighting factors assigned to the parameters, methods of normalizing the parameter data, and methods of combining parameter data and weighting factors. Air Force standardization of trade study methods is recommended.

394. Meister, D., Finley, Dorothy L. and Thompson, E. A., *Relationship Between Sytem Design, Technician Training and Maintenance Job Performance on Two Autopilot Subsystems,* AFHRL-TR-70-20, September 1971. AD 739 591.

The purpose of the study was to investigate the relationship between system design and training variables and performance of technicians. Over a five month period technicians at two SAC bases were observed in troubleshooting the MG-1 and A42G autopilots. Following each maintenance incident the technician was interviewed. At the conclusion of the study maintenance supervisors ranked and rated all technicians in terms of skill level. Data collectors also rated the major design characteristics of the equipments maintained. These ratings were correlated with indices of technician performance and subjected to multiple regression analysis. Those factors contributing a significant amount to performance were extracted. A subjective report test battery was also developed to determine whether subjects could predict their own performance. Four general factors were found to be primarily responsible for maintenance performance: (1) accessibility to and within the equipment; (2) diagnostic information supplied by prime and test equipment, T.O.'s and checklists; (3) equipment structure; (4) general technician capability for handling test equipment. A residual experience factor was relatively unimportant.

395. Mills, G., Shriver, E. L., Carswell, W. and Harris, C., *Guide to Defining and Solving Waiting Line Problems: Volume I, Procedures* AFHRL Technical Report 71-39, Vol. I, June 1971. AD 738 320.

This guide is designed to present techniques for the solution of queuing problems in a form for use by the nonmathematician. It is believed that effective use of these techniques will provide considerable savings in those job areas where waiting time is a costly factor. The guide consists of a series of questions that may be directed toward any queuing problem at hand. The answers to these questions will lead the reader in the direction of a solution or resolution of a problem. The mathematics beyond arithmetic normally required by such problems has been reduced to graphical form. These graphs can be used for most values encountered in a common queuing problem. Additional descriptive material is included in the text which explains these types of queuing problems that this guide does not address, and provides an indication of how such problems might be simplified and how approximate solutions might be reached. This guide is directed toward the common, job-oriented problems and leaves the special cases for more advanced texts.

396. Mills, G., Shriver, E. L., Carswell, W. and Harris, C., *Guide to Defining and Solving Waiting Line Problems: Volume II, Sample Problems.* AFHRL Technical Report 71-39, Vol. II, June 1971. AD 736 032.

Volume II of this guide contains 71 sample problems pertaining to Air Force operations, maintenance, base administration, supply, and transportation. The step-by-step procedure for solving each problem with queuing techniques presented in Volume I is illustrated.

397. Mitchell, R. L., Lucero, A. B., Harrison, R. E. and Arnold, D. J., *Synthesis of High-Resolution Radar Systems for Display Simulation and Training,* AFHRL Technical Report 71-11, June 1971. AD 734 548.

A comprehensive analysis was conducted of the theory and practice of utilizing digital techniques for simulating high-resolution radar systems. The objective was to simulate radar displays of cultural complexes for navigation training. Three major phases of this effort are: (1) develop tractable scattering models, (2) construct a data base, and (3) define a simulation procedure that is computationally efficient. The techniques developed in this report are generally applicable for any radar system, whether of brute-force type or synthetic aperture. To validate the approach, a 30 city-block area is incorporated into a digital data base by using photogrammetric techniques on aerial photography. From this data base, a radar display is simulated that is in good agreement with actual radar imagery. The practicality of a real-time digital simulation is demonstrated.

398. Morgan, R. L., *Implications of Training Research for CAI,* Professional paper presented at "Conference on Application of Computers to Training", sponsored by National Security Industrial Association, Washington, DC. AFHRL-TR-71-35, August 1971. AD 733 339.

A brief description is proved of five general implications of prior training research for contemporary efforts to exploit computers for training. Stated negatively, or as cautions, these five general implications are: 1. Don't act as if computer - based training were something entirely new. Always conceive of computer - based training in such a way that you can relate it to what is known about conditions for effective training. 2. Don't be misled into thinking that a computer offers a training system which is obviously so superior that no evaluation need be made or records kept. 3. Don't just apply the computer to training. Carefully analyze the total training process and apply the computer to those functions that need automation. 4. Don't be seduced by claims that, almost mysteriously profound learning and understanding occur when a trainee "uses a computer to interact heuristically with the subject-matter." Systematic practice with feedback is still the best condition for learning. 5. Don't put all your 'eggs' in any one type of research and development 'basket'. Because of high investment costs and other factors, such as market position, there seems to be a somewhat unhealthy emphasis on an immediate capability.

399. Simons, J. C. and Valverde, H. H., *Voice Communications Training for Forward Air Controller/Strike Target Location*, AFHRL Technical Research Memorandum No. 2, January 1971.

A description is presented of the development and proposed evaluation of a forward air controller voice communications training program. A previous analysis of data obtained from combat recordings revealed the frequency and duration of the items that the forward air controller (FAC) and the tactical fighter pilot (TAC) mutally discuss. The problem of verbalizing imagery (describing to another person what one is seeing) is introduced as a critical FAC-TAC task that appears to depend extensively on subjective skills such as choosing and relating landmarks. The data from the combat tapes indicate skill areas which should receive emphasis in training. It is proposed that these skills may be taught by means of a training program utilizing a forward air controller voice communications trainer. The effort will consist of three phases: Phase I - Analysis and Specification of the FAC Task; Phase II - Development of the Training Course; and Phase III - Program Evaluation. Also see AFHRL-TR-TRM-7, dated April 1971.

400. Snyder, M. T., Manpower, Technology and Air Force Systems. *In Proceedings of the NATO Conference on Manpower Planning Models*, Ed. Clough, D. J., English Universities Press, Cambridge, England, June 1971.

The premise is that design, development and operations of Air Force systems must consider human resources such as manpower, skill requirements, training and sociological factors as well as hardware technology, engineering and organizational processes, or it will be increasingly difficult to develop the human resources posture required to support future operational and technological force structures. Emphasis is on (a) developing models and designing systems to fit predicted available manpower and skills; (b) developing models that depict effects and relationships between characteristics of hardware subsystem design, formal and on-the-job training, job experience and human performance in the wings; and (c) adapting selected operational research techniques to Air Force operational problems that interface with human resources capabilities.

401. Tetmeyer, D. C., *Estimating and Controlling Manpower Requirements for New Systems - A Concept and Approach*. AFHRL Technical Research Memorandum 14, June 1971.

The Air Force faces qualitative, quantitative and budgetary limitations on the number of personnel by AFSC that can be provided to maintain new weapon systems. A systems concept is proposed for manpower prediction and control during the development cycle, using automated data systems and simulation techniques. A plan is presented for a feasibility demonstration during validation phase on the A-X Tactical Aircraft.

402. Valverde, H. H. and Burkett, B. P., *A Systems Approach to C-130E Aircrew Transitional Training*, AFHRL Technical Report 71-4, March 1971. AD 727 055.

This report describes the development and evaluation of a Tactical Air Command (TAC) C-130E transitional aircrew training program based on a systems approach. The systems approach to training emphasizes the importance of specifying objectives derived from a task analysis of the aircrew member's job. A training program was prepared to develop proficiency in the specific duties required of the C-130E pilot, co-pilot, and the flight engineer. The training program was designed to be highly job relevant and included multimedia and self-instructional materials. Training objectives were derived from a task analysis of the C-130E aircrew member's job requirements. Aircrew flight training course materials and various training media were prepared based on the specific end-of-course objectives. The training program was evaluated over a six-month period, revised as needed, and implemented by TAC in the USAF formal school for C-130E transitional training for all military services. The results were as follows: (1) students in the new course achieved all training objectives, (2) classroom instruction was reduced about 50%, (3) flying hours were reduced from 45 to 35 hours, (4) length of training was reduced 37% per trainee, (5) pilots and co-pilots, graduates of the new course, were rated significantly higher by their supervisors than were graduates of the old course, (6) there was no significant difference in ratings received by the two flight engineer groups, and (7) verified annual savings of about five million dollars was realized.

403. Valverde, H. H., "Visual Recon", *Tactical Air Reconnaissance Digest*, June 1971.

Describes the development and evaluation of a visual reconnaissance (VR) training program in the Special Operations School, Hurlbert Field, Florida. One group of 15 pilots received conventional training while another group of 15 pilots received the new course. Members of both groups were FAC students at Eglin. The influence of the training course was evaluated by comparing the proficiency of the two groups on a criterion test based on a behavioral analysis of the FAC VR task requirements. The results of the evaluation showed that the group using the new VR course performed much better than the other group.

404. Valverde, H. H., Corson, D. and Simons, J. C., *Instructions for the Assembly and Operation of the FAC/TAC Trainer*, AFHRL Technical Research Memorandum No. 7, April 1971.

A description is presented of the assembly and operation of the forward air controller/tactical strike pilot (FAC/TAC) trainer. The trainer can be used to improve the FAC's ability to communicate target locations on the TAC. Research has shown that a major communications problem is concerned with the time-consuming factors involved when a low observer (FAC) must verbally describe his field of view to a high observer (TAC). The FAC/TAC trainer can be used to practice skills associated with target location communications between the FAC and TAC. All communications during training sessions are tape recorded by the instructor which permits playback of the students' performance. Additional information on the development of the trainer is contained in Technical Research Memorandum AFHRL (TR) TRM-2, Dated January 1971.

405. Valverde, H. H., Hicks, C. F. and Kearns, N. H., *Development of an RF-4C Refueling Training Program from Computer-Based Systems Data*, AFHRL Technical Report 71-25, June 1971. AD 736 409.

This report describes the development of a systems approach to RF-4C air refueling training. The primary objective of the effort was to develop an instructional plan, or blueprint, using a format which facilities the utilization of existing computer-based task data by training personnel. The training plan was developed for use by Tactical Air Reconnaissance Center instructor personnel in training RF-4C aircrews to effectively perform KC-135 air refueling requirements. Secondary program objectives were to demonstrate and refine the technology for developing other job-specific aircrew training programs using existing computer-based task data. The complete RF-4C air refueling training segment based on task and subtask behavioral objectives is appended. The objectives state the behavior required, the conditions under which the behavior is to be observed, and the standards which the behaviors should meet.

ABSTRACTS FOR 1972

406. Cream, B. W., Valverde, H. H., *Development and Evaluation of Two Functional Part-Task Trainers,* Presented to the Third Annual Psychology in the Air Force Symposium, 17-20 April 1972.

This paper describes two projects conducted by the Air Force Human Resources Laboratory in cooperation with the Tactical Air Command. The first project was designed to provide practice in voice communications pertaining to target location for the airborne FAC and strike pilot. Photographic imagery was used as the display source. The second trainer was designed to provide positive transfer of training for tracking and equipment operation tasks for Forward Looking Infrared (FLIR) and Low Light Level TV (LLLTV) sensor operators aboard Gunship Aircraft. TV video tape was used on the display source. Both trainers have been accepted by the users as providing positive training value to their programs.

407. Cream, B. W., *Evaluation of a Trainer for Sensor Operators on Gunship II Aircraft,* AFHRL Technical Report 72-27, September 1972. AD 750 616.

This report describes the design, development and evaluation of a training device intended to enable ground based practice of equipment operation and target tracking skills that are required by the Forward Looking Infrared (FLIR) and Low Light Level TV (LLLTV) sensor operators assigned to Gunship II aircraft. This trainer makes use of a relatively unique approach to tracking training by using video tape which is electronically manipulated so as to allow tracking in both simulated wide and narrow angle fields of views similar to actual equipment. (The complete description of the video equipment is provided in TR-72-41). In addition, the trainer incorporates both actual and mock-up instruments that enable the trainee to practice equipment operation procedures and malfunction isolation and correction. The evaluation of the training effectiveness of this device showed that sensor operators who received practice on this device reached the desired skill levels for both equipment pre-flight and target tracking sooner than those who had not received such training. As a result of the demonstrated value of this device, the using organization has incorporated it into their formal training curriculum.

408. Eckstrand, G. A., *Human Resources Considerations in the Development of Complex Systems,* Presidential Address presented to Division of Military Psychology, American Psychological Association Convention, 4 Sept 1972. AFHRL Technical Report 72-64.

This paper presents and elaborates the following general thesis: military psychologists will never be more than marginally effective in providing solutions to problems in the areas of personnel, training, operational performance and even job satisfaction unless and until they develop the power, the talent and the technology to have a significant influence on the design of complex military systems and equipment. In todays highly technological military services, the most powerful variable determining what people do, the skills they require, and the environments in which they work is the nature of the weapon systems and support equipment acquired by the services. It is here, then, in this area, that the problems of military psychology must be first addressed. The paper discusses the technology of human resources engineering which refers to the design of a hardware system with regard to its total human resources impact over the life of the system. Five research efforts which are relevant to a technology of human resources engineering are described: (1) the impact of human resources data on system design, (2) the use of human resources data in system design trade studies, (3) use of a simulation model to forecast and control manpower requirements for new systems, (4) relationship between subsystem design, maintenance skill requirements and job performance, and (5) development of a human resources data handbook for systems engineering. The paper concludes with a discussion of some of the broad issues involved in designing organizations and systems against criteria which include the fulfillment and growth of the individuals who will be involved.

409. Foley, J. P., *Description and Results of the Air Force Research and Development Program for the Improvement of Maintenance Efficiency,* Presented at American Psychological Association Convention, 2-8 Sept 72. AFHRL Technical Report 72-72.

This paper is one of three prepared for a 1972 APA Symposium entitled "The Impact of Behavioral Science on the Maintenance of Machine Subsystems". This paper and its accompanying slides give an overview of the Air Force Research and Development Program for the improvement of maintenance efficiency. Some references to related work of other DOD agencies and civilian concerns are also made. It emphasizes the use of the task analysis process in all of these efforts. Although the central theme emphasizes the job performance aids efforts, attention is also given to job oriented training and job task performance tests. The results of two experiments are briefly summarized: (1) an experiment of the Air Force Human Resources Laboratory in which high and medium aptitude subjects with only 12 hours of training successfully accomplished checkout procedures, troubleshooting and remove and replace actions on an electronic equipment using job performance aids and (2) a SAMSO (Space and Missile Systems Organization) experiment entitled PIMO (Presentation of Information for Maintenance and Operation) in which experienced technicians, apprentice technicians, and personnel from unrelated career fields accomplished error free maintenance on all types of flight line maintenance tasks except troubleshooting on the C-141 aircraft. In addition, a 1972 demonstration combining job performance aids with job oriented training is described. In this demonstration, successful flight line and field shop maintenance of a doppler radar and its computer were performed by Airmen of both high and average electronic aptitude after only four weeks of job oriented training if they used job performance aids.

410. Foley, J. P., *Task Analysis for Job Performance Aids and Related Training*, Presented at Conference on Uses of Task Analysis in the Bell Systems, Hopewell, New Jersey, 18-20 Oct 72. AFHRL Technical Report 72-73.

This paper presents several aspects of task analyses for maintenance jobs when these analyses are used as bases for the development of job performance aids (JPAs) and job oriented training. It starts with a brief history of the development of task analysis technology and the part that Air Force research has played in this development. A formal structure is required when such task analyses have many uses. The fact that task identification is but the first step in any task analysis is emphasized. After tasks are identified, the type of analysis depends on the purpose for which the analysis is being made. Job observation, questionnaire, interview, and hardware analysis are some means that are available for identification of job tasks. Task identification, based primarily on hardware analysis, is the most appropriate basis for maintenance jobs. A scheme or format to accomplish this, called a Task Identification Matrix, is presented and described. A structured scheme for analyzing the identified tasks for JPA development is also presented and includes documents such as the Task Description Index and Management Matrix, Task Step Data Detail Test Equipment and Tool Use Form. For maximum effectiveness and efficiency, JPAs and training should be developed to effect optimum trade off between training and JPAs. The analytic questions concerning training which must be answered by a task analysis for JPA developers and training specialist are introduced and plans for a scheme for accomplishment are mentioned.

411. Lintz, Larry, M., Loy, Susan L., Hopper, R. and Potempa, K. W., *Relationships Between Design Characteristics of Avionics Subsystems and Training Cost, Training Difficulty, and Job Performance*, AFHRL-Technical Report 72-70. September 1972.

The relationships between subsystem design characteristics, training cost, training difficulty, and job performance were investigated for avionics subsystems. A list of relevant design characteristics was established, based on expert opinions of avionics engineers, Air Force (AF) training supervisors, and AF instructors. Functional loops were selected from 10 subsystems representing navigation, flight control, communications, and fire control subsystems. Performance examinations for each of the 30 functional loops were identified or constructed. Ten AF students performed each of the examinations. Time and errors were recorded for using equipment and reading technical orders (T.O.). Both stepwise regressions and factor analysis were used to derive equations to predict performance time, training time, T.O. time, errors, and training equipment cost from equipment design characteristics, personnel characteristics, and environmental variables. Multiple correlation coefficients were 0.88 and greater. Factors of Length of Checkout Procedure, Equipment Complexity, Difficulty of Checkout Steps, Nonautomatic Checkout, Diagnostic Information, and Clarity of Information were identified. Addition research is recommended.

412. Luckew, R. S., *The Use of Simulation Models for Decisions Pertaining to the 'Best' Mix of Aircraft, Support Personnel, Spare Parts, and Level of Repair*, AFHRL Technical Report 72-57, December 1972.

Recently Tactical Air Command changed their maintenance plan so that now the entire Air Force is on a 66-1 maintenance concept. Flight line maintenance personnel will be available to do shop work under this concept. The Air Force is also changing their method for determining spare levels with the advent of the Advanced Logistics System. These two changes will have an impact on many of the decisions made during the development of a weapon system. One of the largest impacts will be in the logistics area, especially level of repair analysis. This report describes the current state of the technology available for decisions which determine the level of repair or discard (LOR) policies. A methodology based on the research which defined the state of LOR technology is recommended which considers both the availability of flight line personnel to do shop work and the new spare level policy of the Air Force.

413. Regulinski, T. L., Askren, W. B., *Stochastic Modeling of Human Performance Effectiveness Functions*, Proceedings 1972 Annual Reliability and Maintainability Symposium, pp 407-416, IEEE Catalog Number 72CH0577-79, January, 1972.

Human performance effectiveness functions of Reliability and Correctability are mathematically modelled in stochastic, time continuous domain from error data experimentally generated by tracking and vigilance tasks. The probability density functions governing the random variables time-to-error, and time-to-error-correction are isolated using the Kolmogorov-Smirnov test and the Likelihood Ratio test. A number of task performance predictions are reported based on the Weibull, and Lognormal density functions.

414. Valverde, H. H., Woods, W. J., Kearns, N. H., *Evaluation of a Device to Train Forward Air Controllers to Communicate Target Locations*, AFHRL Technical Report 72-12, May 1972. AD 751 292.

This report describes the development and evaluation of a forward air controller (FAC) and tactical strike pilot (TAC) trainer. The trainer was designed to permit a FAC and a TAC to practice the tasks of communicating the location of targets. A previous analysis of communications between FAC and TAC personnel during actual combat had revealed that the task of verbalizing imagery (describing what one is seeing) was especially difficult and important to the success of the FAC/TAC mission. Subjects for the evaluation consisted of 35 Air Force pilots selected to be trained as forward air controllers at Hurlburt Field, Florida. The subjects were divided into 2 groups: Group A (N=18) received a one-hour pretest, two hours of supervised practice, and then a one-hour posttest. Group B (N=17) received only a one-hour pretest and a one-hour posttest. The achievement in gain of Group A was significantly greater than that of Group B. The results of a student questionnaire indicated that the FAC students enthusiastically endorsed the use of the trainer in teaching communication of target locations. The results of transfer of training were inclusive. These results about transfer are not surprising because performance in the aircraft was evaluated using a subjective and rather gross scale.

415. Welde, W. L. and Cream, B. W., *Variables Influencing the Perception of Flicker in Wide Angle CRT Displays*, AFHRL Technical Report 72-4, December 1972.

An experiment was conducted to determine the influence of three variables on the perception of the psychophysical phenomenon of flicker in wide angle CRT displays. The three independent variables treated in the experiment were: 3, 6, and 9 FL illumination levels; four images of which three were static and one was dynamic; and 26 fixation points positioned around a display from 0 to 120° in the horizontal axis and 60° down to 90° up in vertical axis. Recorded measures in the factorial experiment consisted of time to the first observation of flicker, percentage of the total numbers of trials that flicker was observed, and the severity of flicker regarding it interference with a visual task. Analysis of variance tests were applied to the experimental data. Conclusions drawn from the experiment are: (1) flicker will probably be encountered at all illumination levels between 3 and 9 FL; (2) the most prominent flicker effects will be encountered when fixating at a point 30° from the source of illumination with flicker being observed out to 120° horizontally and to +90°/-60° vertically; (3) the severity with which flicker interferes with a primary visual task is not expected to exceed a noticeable to moderate level of distraction; (4) subject differences are considerable in the perception of flicker, but each individual is fairly consistent in his sensitivity to flicker; (5) some individuals are prone to experiencing spatial disorientation when the display system presents a moving image, and further research is recommended on this phenomenon.

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